By permission of the National Portrait Gallery.

This engraving presents forty-eight of the most distinguished men in Science living in England in 1807–1808 assembled in the Library of the Royal Institution. The engraver was William Walker. The grouping was designed by Sir John Gilbert, R.A., and the figures were drawn by John Frederick Skill. Chemists represented in the group are Sir Humphry Davy, Henry Cavendish, John Dalton, Daniel Rutherford, William Hyde Wollaston, Charles Hatchett, William Allen, Thomas Thomson, Count Rumford, William Henry, and Charles Tennant. The figure at the extreme right represents Bramah, the inventor of various pumps, presses and fire-engines. As no portrait of Bramah existed, the engraver placed him with his back to the observer.

TORCHBEARERS OF CHEMISTRY

PORTRAITS AND BRIEF BIOGRAPHIES OF SCIENTISTS WHO HAVE CONTRIBUTED TO THE MAKING OF MODERN CHEMISTRY

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WITH BIBLIOGRAPHY OF BIOGRAPHIES

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Foreword

More than twenty years ago Mrs. Forris Jewett Moore presented the Department of Chemistry at the Massachusetts Institute of Technology with a generous gift of money the income of which was to be used to promote an appreciation of the cultural value of chemistry. Certainly nothing could have been better conceived to perpetuate the influence of Professor Moore's charming lectures on the history of chemistry. Indeed a generation of students came to realize the cultural significance and continuity of science as well as the sincerity and devotion of the "saints of science." A small private collection of portraits of chemists had already been placed on the walls of one of the corridors of the chemistry portion of the Institute and an early employment of the Moore Fund was accordingly used to increase this collection to scientific thought or systematized positive knowledge. To Professor Smith belongs the credit for securing an unusual collection of portraits on his trips abroad. This original collection has now been further increased by Professor Smith and brought together in this volume, which is believed to be unique and comprises a delightful form of the history of chemistry. The value of the book is very real and immediate. It also emphasizes the essential difference between the present and earlier civilizations. These men of science, so few out of the ruck of mankind, have in our period made knowledge more accurate, more extensive, and enormously deeper and certain than is recorded in any previous civilization of which any verifiable knowledge exists.

Perhaps it is not too much to hope that this pleasant record will stimulate reflection on the nature of progress. Science at the time of the Greek miracle was as impressive as the work of the sculptors, writers and architects. "Greek civilization," Professor George Sarton reminds us, "ended in failure, not because of lack of intelligence but because of lack of character or morality." An awareness of the implications of the history of science no less than those of the history of political events may save us from being condemned to repeat the errors.

FREDERICK G. KEYES

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The Spirit of Chemistry

"For they are not given to idleness, nor go in a proud habit, or plush and velvet garments, often showing their rings upon their fingers, or wearing swords with silver hilts by their sides, or fine and gay gloves upon their hands, but diligently follow their labours, sweating whole days and nights by their furnaces. They do not spend their time abroad for recreation, but take delight in their laboratory. They wear leather garments with a pouch, and an apron wherewith they wipe their hands. They put their fingers amongst coals, into clay, and filth, not into gold rings. They are sooty and black like smiths and colliers, and do not pride themselves upon clean and beautiful faces." — *Paracelsus, 1493–1541.*

"The chemists are a strange class of mortals impelled by an almost insane impulse to seek their pleasure among smoke and vapor, soot and flame, poison and poverty. Yet among these evils I seem to live so sweetly that may I die if I would change places with the Persian king." — *J. J. Becher, 1635–1682.*

"It is truth alone that we desire to know and what a joy there is in discovering it." — *Scheele, 1742–1786.*

"I devote every moment to labours which I hope will not be wholly ineffectual in benefiting society and which will not be wholly inglorious for my country hereafter, and the feeling of this is the reward which will continue to keep me employed." — *Davy, 1778–1829.*

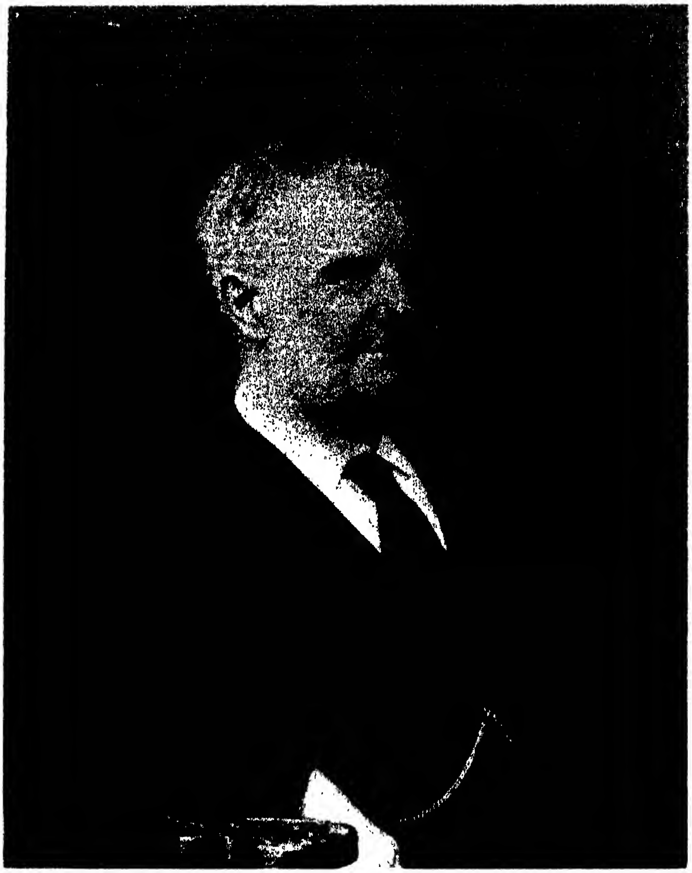
"First and foremost I should emphasize the overwhelming importance of perfect sincerity and truth; one must purge oneself of the very human tendency to look only at the favorable aspects of his work, and be ever on the lookout for self deception (which may be quite unintentional). Next, one should never be content with a conventional experimental method or scientific point of view; one should be open-minded as to the possibility that the procedure or hypothesis may be incomplete. Each step should be questioned, and each possibility of improvement realized. And then patience, patience! Only by unremitting, persistent labour can a lasting outcome be reached." — *Theodore William Richards, 1868–1928.*

Acknowledgments

The following group of portraits originated from a small private collection which was placed on the walls of the Chemistry Department of the Massachusetts Institute of Technology. As first assembled only the name of the chemist was attached to the portrait but later brief biographies were added. The compiler acknowledges the aid and co-operation of the Chemistry Department through the F. J. Moore Fund in developing the original collection. The collection as here assembled has been enlarged and the biographies have in many cases been rewritten and extended. The compiler also wishes to express his appreciation to Dr. R. E. Oesper for his courtesy in compiling the bibliography.

RICHARD ABEGG: 1869–1910.

Professor at Breslau. He worked in physical and electro-chemistry on osmotic pressures, freezing-point depressions in dilute solutions, dielectric constants, the speed of translation of ions and chemical equilibrium. Tested Faraday's Law. Developed the theory of secondary valence. Editor of "Handbuch der anorganischen Chemie" (four volumes) and several smaller works. Editor of the *Zeitschrift für Elektrochemie*. Killed in a free balloon flight.



SIR FREDERICK AUGUSTUS ABEL: 1827–1902.

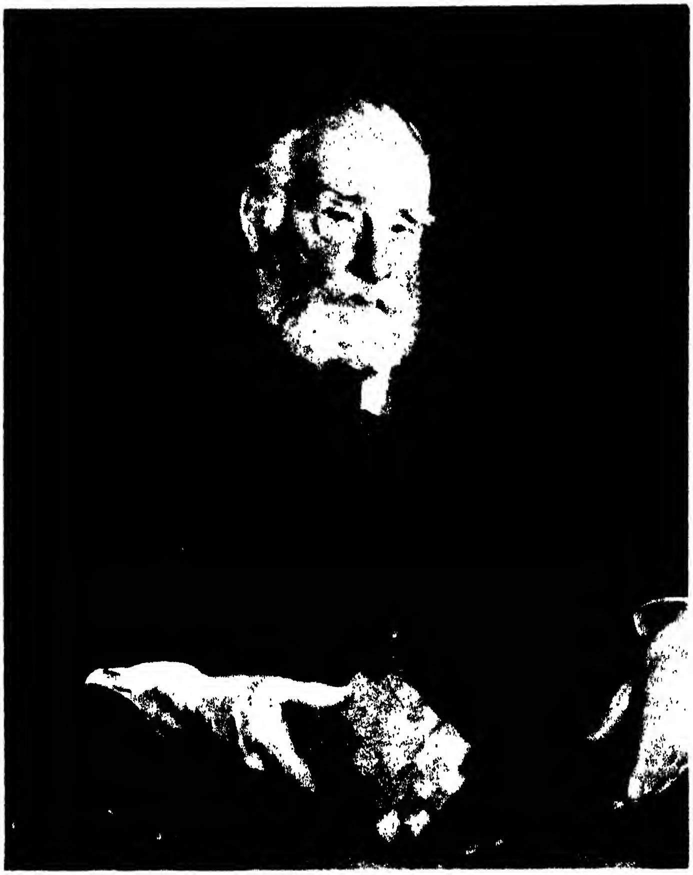
Successor of Faraday at the Royal Military Academy, Woolwich. He did much to develop high explosives, smokeless gunpowder, and introduced the use of cordite in the British Army. With Nobel he studied the relation between the form and size of the grain of the powder and the speed of the projectile. He worked on guncotton and nitroglycerine, also on mine and dust explosions. In studying the hardening of steel for armor plate he showed the formation of Fe_3C. His life was a succession of narrow escapes from explosions of the most violent kind.

ALBERTUS MAGNUS: 1193–1280.

Count of Bollstädt; Dominican monk; Bishop of Ratisbon, which office he resigned to devote himself to his experimental studies. He had the alchemists' point of view of his time and wrote a treatise, *De Alchemia*. He also wrote a series of precepts for those wishing to undertake alchemical studies; one was to be "silent and secret" and another was "not to embark on these undertakings unless provided with ample funds." Distinguished for his chemical knowledge which brought upon him the imputation of sorcery.

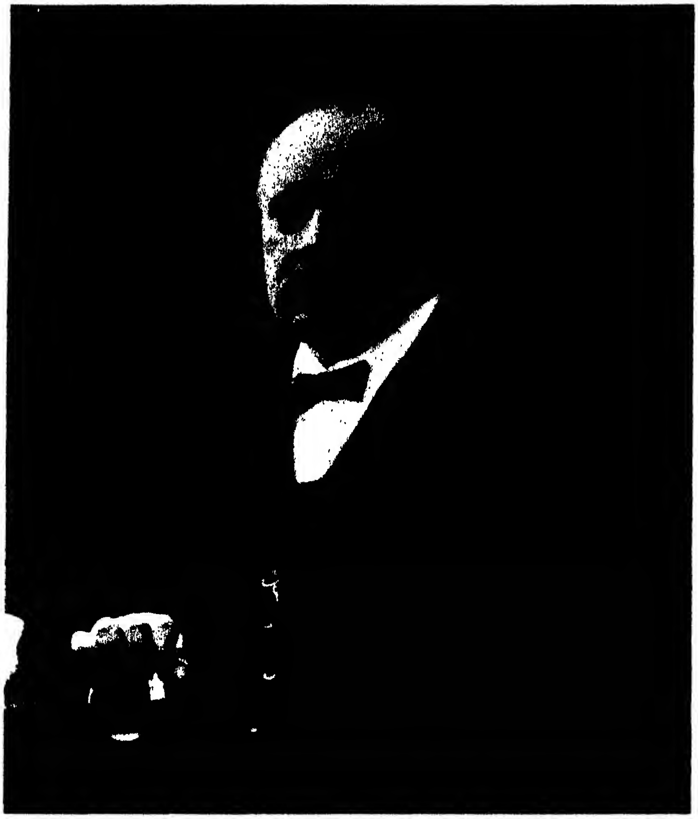
ANDRE MARIE AMPÈRE: 1775–1836.

Physicist and Mathematician. Professor at the Collège de France (1824). He announced the electrodynamic theory and held that electricity and magnetism were identical (1822). Invented the astatic needle and showed that two parallel conductors attract each other if the current flows through them in the same direction. Proposed the theory that currents of electricity circle the earth. The ampere, the unit of rate of electrical flow, was named in his honor.



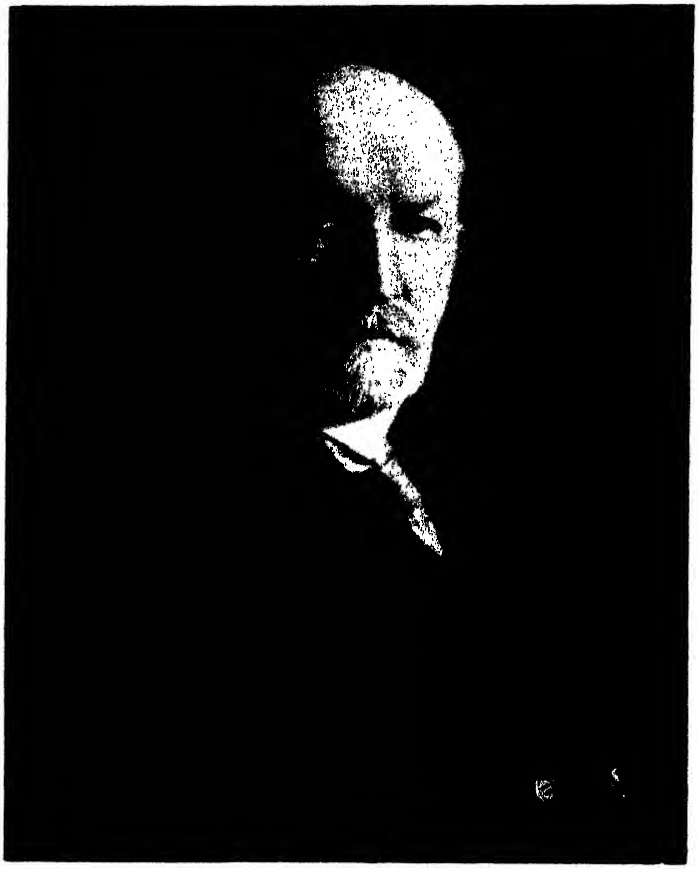
HENRY EDWARD ARMSTRONG: 1848–1937.

Studied under Frankland and Kolbe. Professor at South Kensington. A man of strong individualism and independence in his views. He opposed the new theory of ionic dissociation and spoke of Arrhenius, Ostwald and Van't Hoff as "the three musketeers." Suggested the "centric" formula for the benzene ring (1887). His main research lay in the field of substitution in the naphthalene molecule and he studied the di- and tri- substitution derivatives. In his desire to support the developing dye industry in England he was accustomed to appear on formal occasions wearing a waistcoat dyed in the brilliant hues of red, blue, green or purple of some new dye.



SVANTE AUGUST ARRHENIUS: 1859–1927.

Swedish chemist. Professor in Stockholm. By the age of twenty-four he had formulated his theory of electrolytic dissociation which he presented for his doctorate at the University of Upsala. This theory met with hostile reception by many leaders among whom was Lord Kelvin, and it was only by the energetic support of Ostwald that it finally gained acceptance. Van't Hoff, too, was an early supporter and called attention to the similarity of the gas laws and solutions. Ostwald published Arrhenius's paper "On the Dissociation of Substances in Aqueous Solutions" in the first volume of his newly established *Zeitschrift für physikalische Chemie* in 1887. The hostility towards Arrhenius and his theory became so great that before he was appointed to the professorship at Stockholm his opponents obliged him to undergo an examination as to his scientific qualifications before a committee of three, one of whom was Kelvin. Arrhenius was later interested in such diverse subjects as serum chemistry and astronomy. He speculated on the origin of life on the earth in his books "Worlds in the Making" and "Life on the Universe." He received the Davy Medal, 1902 and the Nobel Prize, 1903.



KARL FRIEDRICH VON AUWERS: 1863–1939.

Studied with Hofmann and Victor Meyer. Professor at Heidelberg (1890), Greifswald (1900), and Marburg (1913). Worked on the isomerism of the oximes and the Beckmann rearrangement; developed the spectrochemistry of organic compounds and the naphthalene, anthracene and acridine derivatives of pyrazole.

AMADEO AVOGADRO: 1776–1856.

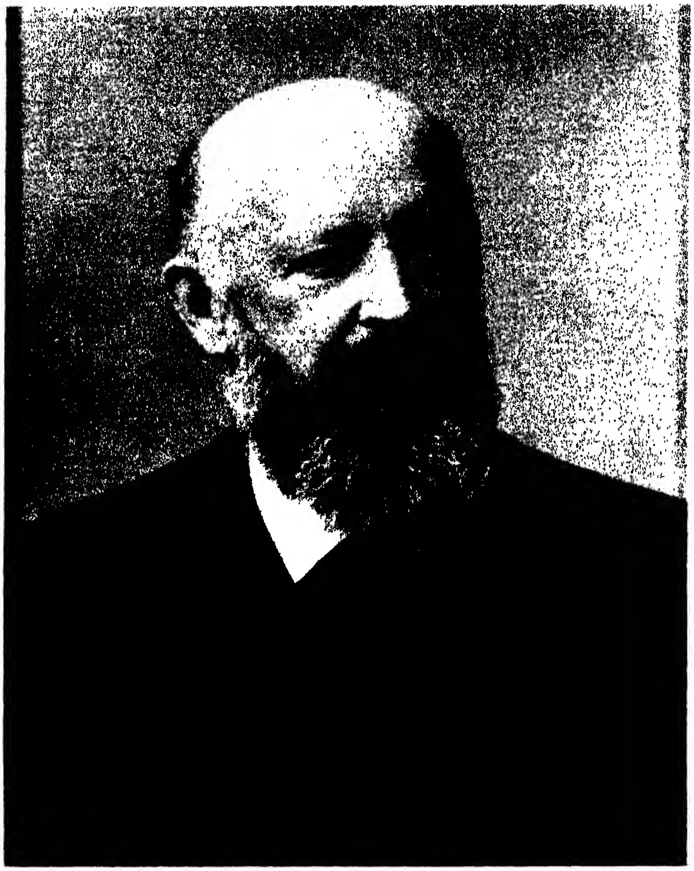
Professor of Physics at the University of Turin (1820). In 1811 he proposed the hypothesis associated with his name and was thus the first scientist to distinguish between the atom and the molecule. The hypothesis was not appreciated until Cannizzaro in 1860 explained its full meaning to a perplexed scientific world at a congress held in Karlsruhe. His generalization known as "Avogadro's hypothesis" has been of the very highest importance in the development of chemistry. In September, 1911, one hundred years after he announced his hypothesis, a monument was unveiled in his honor in Turin in the presence of the King and scientists from all over the world.

FRANCIS BACON, BARON VERULAM, VISCOUNT ST. ALBANS: 1561–1626.

Lord Chancellor of England under James I. Famous as a jurist and philosopher and believed by some to have written the works ascribed to Shakespeare. Bacon was not an experimental scientist but his system of inductive logic gives the basis of scientific thinking. In his *New Atlantis* he created an institution which he called "Solomon House," a research laboratory, wherein he proposed "to find the knowledge of all causes." The members were to conduct experimental researches in health, food, fabrics, transportation in the air, on land and on and under water. He thus conceived the foundations of modern experimental research.

FRIAR ROGER BACON: 1214–1294 (*circa*).

Franciscan monk; leading English alchemist; known as "doctor mirabilis." His writings constitute an encyclopedia of the sciences of his time. Fearless and aggressive in maintaining his ideas he was frequently in trouble with his ecclesiastical superiors and was confined for twenty years and by some reports without books, writing materials or instruments. Although he believed in Alchemy, Astrology and the Philosopher's Stone, he was a true scientist and insisted on experimental proof of all theories. His keen mind and critical attitude made him a forerunner of the Renaissance. He was the first European to describe the preparation of gunpowder.



ADOLF von BAEYER: 1835–1917.

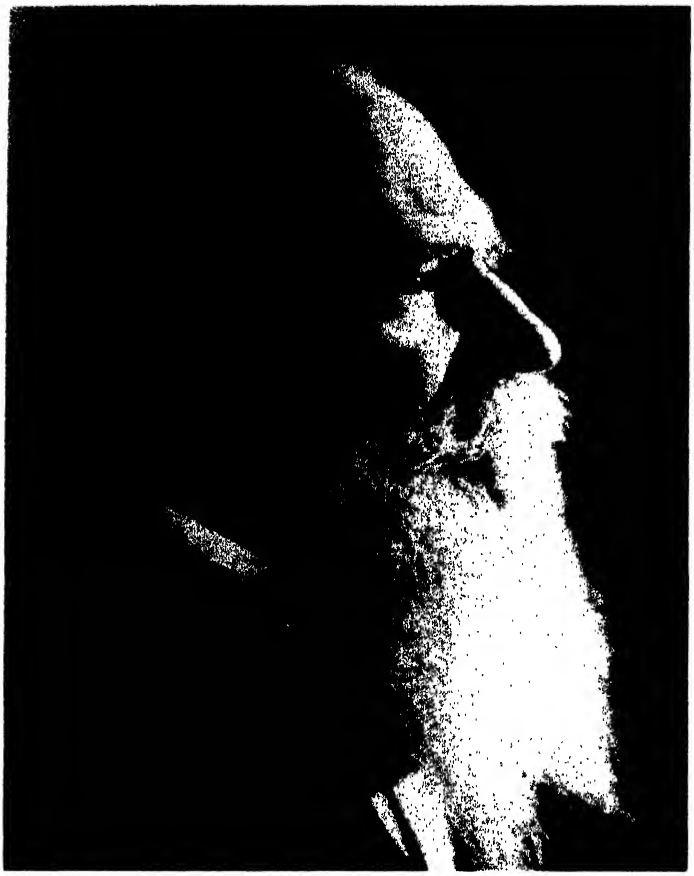
One of the great men of modern organic chemistry. A pupil of Bunsen and Kekulé. He succeeded Liebig as Professor of Chemistry at Munich (1875). His researches enriched many departments of organic chemistry. The most famous was with indigo, on which he worked for a quarter of a century (1866–1890) in determining its constitution and final synthesis. He investigated the phthaleins; uric acid; the purines; the terpenes, the structure of benzene (centric formula), and the basic properties of oxygen. Discovered aspirin. Received the Nobel Prize, 1905, for his work on organic dyes and hydroaromatic compounds.

ANTOINE JEROME BALARD: 1802–1876.

As a pharmacist in Montpellier he noticed that the mother liquors of the salt marshes of the Mediterranean near Montpellier showed a yellow color after oxidation. He extracted this brine with ether and obtained a red liquid which he sealed in a tube and sent to the French Academy (1826). Gay-Lussac was appointed to examine and report on the substance and later announced the discovery of bromine. Liebig is reported to have said that considering its odor "Balard had not discovered bromine as much as bromine had discovered Balard." Balard was called to succeed Thénard at the Sorbonne. He determined the constitution of Javelle water and discovered hypochlorous acid.

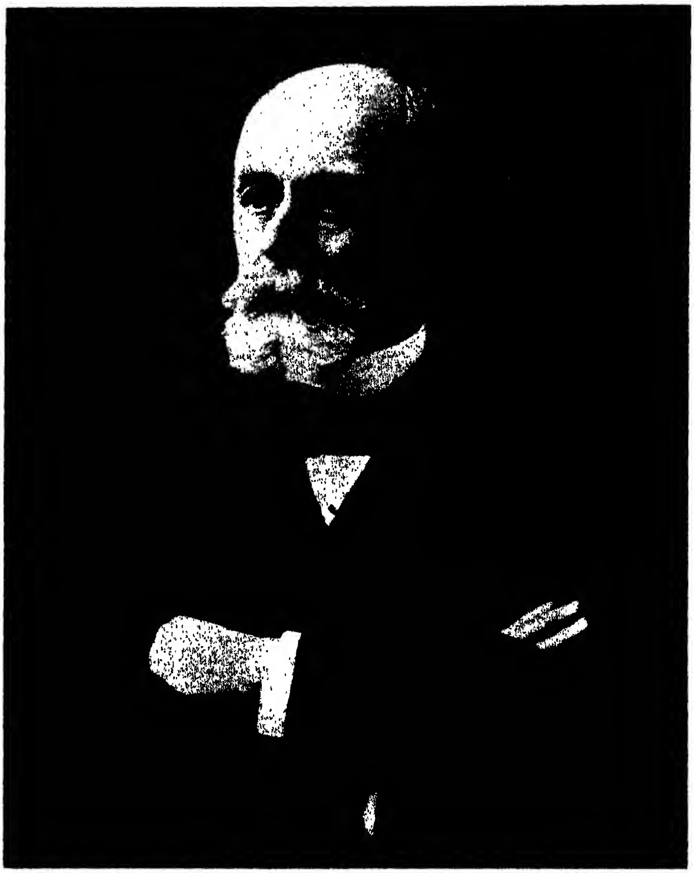
JOHANN JOACHIM BECHER: 1635–1682.

German alchemist and Court Physician to the Emperor of the Holy Roman Empire. Divided matter into three "principles," *terra mercurialis*, *terra vitra*, and *terra pinguis;* the latter, *terra pinguis*, he believed was the principle of combustion. His ideas supplied to his pupil, Stahl, the foundation for the phlogiston theory. Showed that sugar is necessary for fermentation (1680). Proposed many industrial schemes which were unsuccessful and kept him in constant difficulties with his creditors. Engaged by the Dutch Government to make gold from sea sand. He suggested distilling coal to obtain tar for preserving wood, but the world had yet two hundred years to wait for a coal-tar industry! Wrote *Physica Subterranea* and *Methodus Didactica*. Buried in the chancel of St. James-in-the-Fields, London.



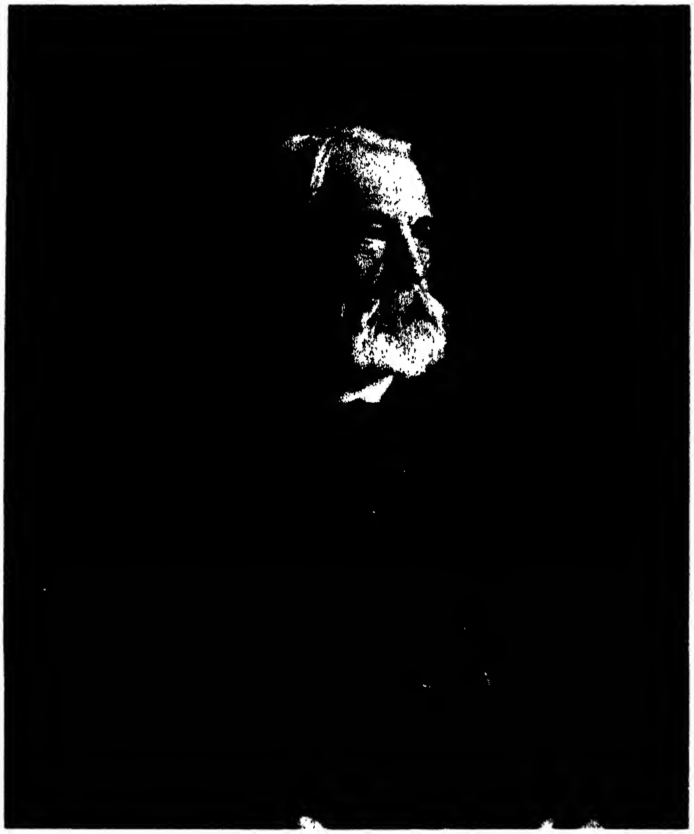
ERNST OTTO BECKMANN: 1853–1923.

Professor at Erlangen (1892), Leipzig (1897), and Director of the Kaiser Wilhelm Institut (1912). Beckmann is best known for his discovery (1886) of the molecular rearrangement which occurs in oximes and named the "Beckmann Rearrangement" by Victor Meyer. Developed the freezing and boiling-point methods of molecular weight determinations and designed the thermometer known by his name. Contributed to spectrum analysis and worked on camphor. He had a golden humor and the faculty of awakening the joy of work in his pupils. No teacher was ever more beloved by his associates and students.



HENRI ANTOINE BECQUEREL: 1852–1908.

Professor at the École Polytechnique (Paris). Studied the phenomenon of fluorescence and discovered the radioactivity of uranium and its salts. He also noted that the mineral pitchblende was more active than the uranium or the uranium salts obtained from it. It was at the suggestion of Becquerel that Madame Curie undertook the chemical examination of pitchblende which led to her discovery of radium. Received the Nobel Prize (1903) jointly with the Curies.



FRIEDRICH BEILSTEIN: 1838–1906.

Studied with Bunsen, Liebig and Wöhler. Professor at St. Petersburg. His researches in organic chemistry contributed to the knowledge of the position of the substituted groups in the aromatic series. His fame rests on his "Handbuch der organischen Chemie." For twenty years Beilstein worked single handed late into the night compiling the material for this monumental work which was first published in 1880. Greatly expanded subsequent editions have appeared. No research laboratory of organic chemistry could exist today without a "Beilstein."

TORBERN OLOF BERGMAN: 1735–1784.

Professor at Upsala. Developed analytical methods, including the use of the blowpipe; classified minerals and laid the foundations for mineralogical chemistry. Studied "aerial air" (CO_2), alum, and methods for the quantitative determinations for calcium, lead, and sulfuric acid, and for analyzing waters. Predicted the discovery of tungsten and molybdenum (1778). His precision and clearness of expression increased the understanding of chemical affinity. He was a friend and benefactor of Scheele.

MARCELLIN PIERRE EUGÈNE BERTHELOT: 1827–1907.

A pupil of Balard and later Professor of Chemistry at the Collège de France. He was a pioneer in gas analysis, thermochemistry, the chemistry of explosives and organic synthesis, and made contributions of the greatest value to the history of early chemistry and of alchemy. He also attained high political honors, serving his country as Minister of Public Instruction and as Minister of Foreign Affairs. Buried in the Pantheon.

CLAUDE LOUIS BERTHOLLET: 1748–1822.

Professor at the École Normale; filled many positions of responsibility in the Government. He early (1785) declared himself in favor of Lavoisier's new theories of combustion. Assisted Lavoisier in revising the vague chemical nomenclature of that time with the systematic one in use today. Showed the presence of nitrogen in animal matter (1791); proved the composition of ammonia, hydrogen cyanide, and hydrogen sulfide and studied potassium chlorate; discovered cyanogen chloride and chlorine hydrate (1785). Introduced the use of "Eau de Javelle" (1800) for bleaching and refused a patent for the process. Showed the errors of Geoffroy's tables of affinities (1801) and announced that the determining factors were associated with the relative masses of the reacting substances. His belief that varying proportions were possible in a compound resulted in his famous controversy with Proust that lasted over a period of years (1801–1807) and resulted in Proust's establishment of the Law of Definite Proportions. Born in humble circumstances he became a Count of the Empire under Napoleon.

JÖNS JAKOB BERZELIUS: 1779–1848.

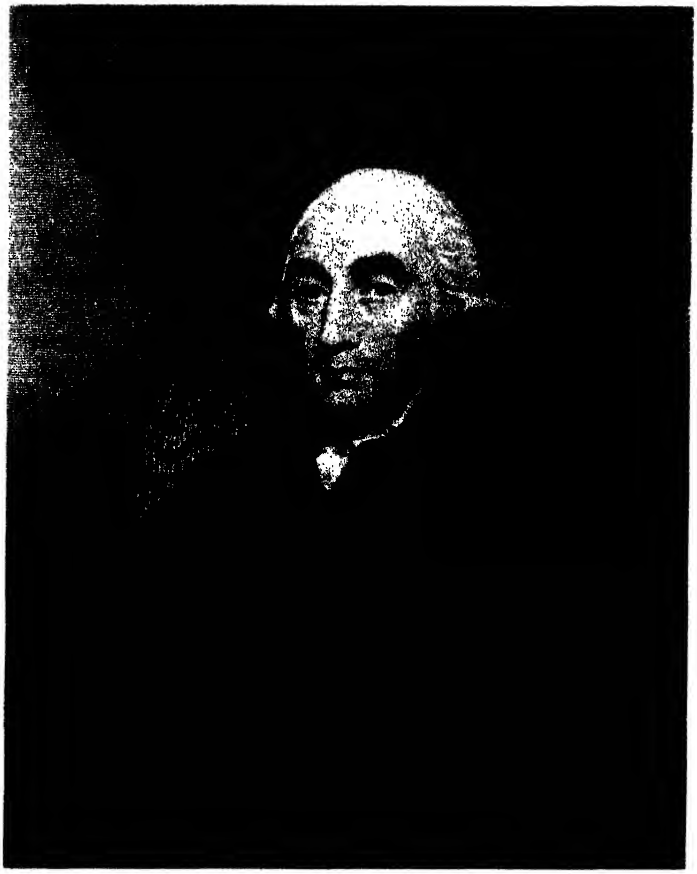
A Swedish chemist, for fifty years a professor at Stockholm and well entitled to be considered as one of the founders of the science. He originated the present-day symbols of the elements and their use in the formulae for the compounds (1814). As a pioneer in the determination of accurate atomic weights (1817) he contributed to the establishment of Dalton's theory. He proposed a dualistic or electrochemical theory (1812) which dominated chemical thought for many decades. Berzelius discovered ceria (1803), selenium (1817), silicon (1823) and thorium (1828). His fame drew to his laboratory such pupils as Rose, Mitscherlich, Wöhler and many others. He married late in life and at the ceremony a letter was read from King Charles creating him a Baron. His large textbook and his annual reports on the progress in chemistry exerted a profound effect on chemical thought.

SIR HENRY BESSEMER: 1813–1898.

Son of a French refugee who fled to England to escape the Terror. From earliest years he was an inventor of such diverse articles as a non-duplicable stamp to a bronze for type. The demand for steel in the Crimean War led him to turn his attention to the manufacture of this article about which he knew nothing. After many months of experimenting the thought occurred to him of making cast iron malleable by burning out the carbon by a blast of air. He constructed a furnace five feet high and three feet in diameter and at the first attempt he produced seven hundred pounds of steel. The process was reported to the British Association on August 11, 1856 and within a few weeks he had sold $125,000 of licenses for the process. When, later, a large plant was erected under Bessemer's supervision, the product was only a good grade of cast iron and the process was called a failure. Bessemer bought back all his licenses and studied the cause of the failure, which he found to be due to phosphorus in the ore. On using a phosphorus-free ore the process was again satisfactory. The process spread to all lands and Bessemer received honors and wealth.

SIR HENRY BESSEMER: 1813–1898.

Caricature of Bessemer by the famous cartoonist "Spy," entitled "Steel," appearing in *Vanity Fair* as a colored supplement November 6, 1880.



JOSEPH BLACK: 1728–1799.

Professor at Glasgow and Edinburgh. His investigations (1750) on "Magnesia alba" ($MgCO_3$) and "Magnesia usta" (MgO) and the loss of "fixed air" (CO_2) on heating showed the existence of carbon dioxide in the free and combined state and hence classified the relation between mild and caustic alkalies. He also showed the loss in weight of the carbonate on heating which was directly opposed to the claims of the phlogistists who stated that on heating the carbonate absorbed phlogiston from the air and thus a gain in weight was to be expected. This work of Black did much to overthrow the phlogiston theory. Black also evolved the theory of latent heat (1762) which later led his pupil James Watt to the invention of the steam engine.

HERMAN BOERHAAVE: 1668–1738.

Professor of Medicine, Botany and Chemistry (1718) at the University of Leyden. His system of chemistry was the most learned and complete that the world had seen and students flocked to his lectures from all nations. A group of his students using their lecture notes issued (1724) an unauthorized edition which purported to be his lectures. Boerhaave was so incensed that he resigned his professorship but was later induced to reconsider his action and to publish an authorized edition, "Elementa Chemiae" (1732). This was enormously successful and appeared in over twenty-five editions and was translated into French, English and German. The pirating of his lectures caused Boerhaave to insert in the authorized edition an autographed statement reproduced in the insert above.

"In order that the reader may be certain that this work is mine I have thought it proper to subscribe my name with my own hand lest the work be mistaken for mine when this signature is absent." — H. Boerhaave.

PAUL ÉMILE LECOQ DE BOISBAUDRAN: 1838–1912.

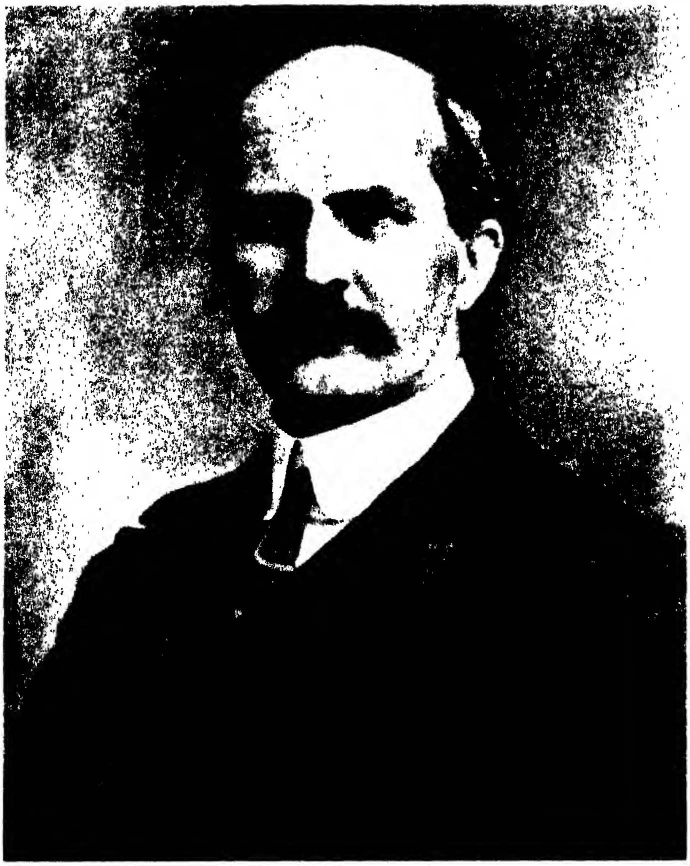
Studied with Kirchhoff, Bunsen and Crookes. Held no academic position and most of his work was done in his own small laboratory. Although he worked in Agricultural and Physical Chemistry his work with the spectroscope is his outstanding contribution to Science. He discovered a relation existing between the lines emitted by members of the same family of metals and their atomic weights and developed the use of the spark spectra in place of the flame. In applying his studies to the elements of the aluminum group he examined some sulfide ores of zinc from the Pierrefitte mines with the discovery of a new, strong violet line in its spectrum. He demonstrated this experiment before the French Chemical Society and proposed the name of *Gallium* for the new element (1875). The properties of gallium were later identified with those predicted by Mendeléeff for the element eka-aluminum. Later when larger quantities of ore were available Boisbaudran, with Jungfleisch, prepared sixty-two grams of metallic gallium. Other investigations of Boisbaudran were with the rare earths, resulting in the identification of Samaria (1875), Dysprosia (1886) and Gadolinia (1889).

JEAN BAPTISTE BOUSSINGAULT: 1802–1887.

Professor at Lyon and the Conservatoire des Arts et Mètiers, Paris. French agricultural chemist who applied his scientific training to improving French agriculture. Studied plant physiology and the nutritive value of fodders. Worked with Dumas and studied the gases of the air. As a young man working in some mines of South America he noted the prevalence of goiter among the natives in some communities and its absence in other places. He analyzed the salt used and came to the conclusion that it was the absence of iodine that was the cause of the trouble and recommended the use of "iodized" salt (1833).

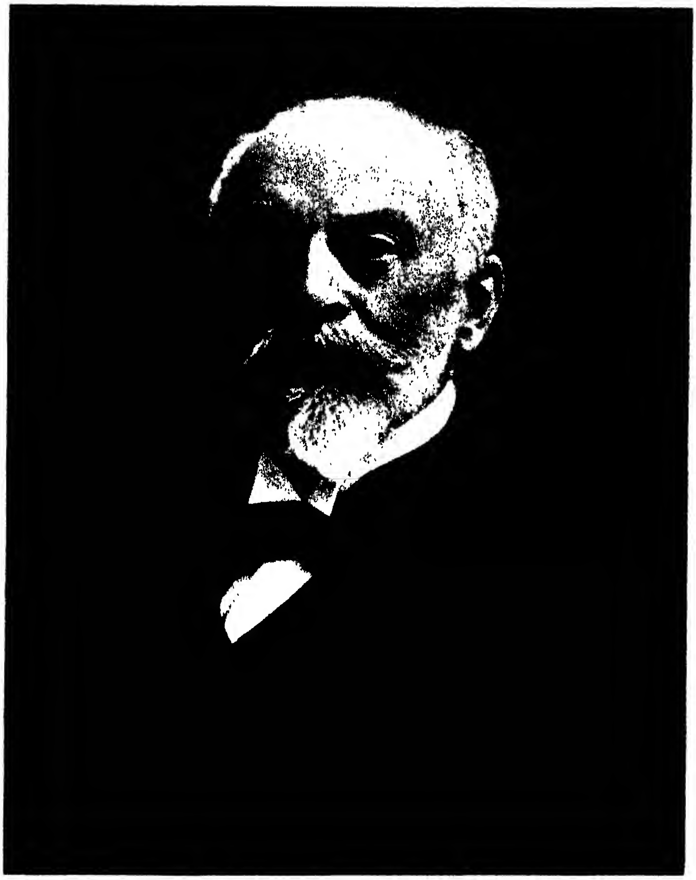
ROBERT BOYLE: 1627–1691.

Son of the Earl of Cork. Resided at Oxford. Born to wealth and nobility he devoted himself to the cultivation of science. The spirit of pure investigation free from alchemistic fetters animated all his work. Though his scientific reputation was unrivalled he was most modest and unpretentious. Believed in the corpuscular structure of matter and was first to distinguish between mixtures and compounds. Used the term "analysis" in the chemical sense. Discovered "Boyle's Law" (1660), methyl alcohol (1661), and phosphoric acid. Noted the darkening of silver salts by light. Author of "The Sceptical Chymist" (1661) in which he attacked the alchemical notion of the elements and defined the term "element" in the modern sense. One of the founders of the Royal Society.



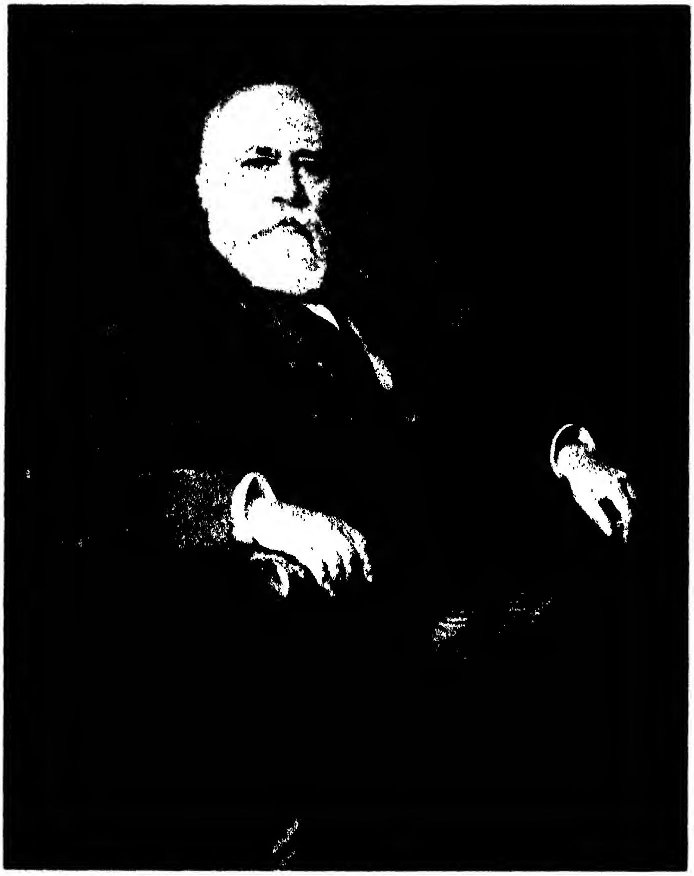
WILLIAM HENRY BRAGG: 1862–1942.

Professor at the University College, London (1915) and the Royal Institution (1923). Important pioneer in the development of the science of crystal analysis by X-rays. He began his studies on crystal structure in 1912 and developed new methods for measuring the wavelengths of X-rays. Determined the arrangement of the atoms in the crystal and announced that in crystals the molecules no longer exist but are replaced by regularly spaced atoms in closely packed arrangement. His son William Lawrence Bragg, Professor of Physics in Owens College, shared in these investigations and they jointly received the Nobel Prize in 1915. Professor Bragg's Christmas Lectures for children given at the Royal Institution were famous. One series was issued in book form under the title "Concerning the Nature of Things" (1925).



JULIUS WILHELM BRÜHL: 1850–1911.

Pupil of Hofmann, assistant of Landolt, Professor at Lemberg and Heidelberg. He investigated the relation between the constitution of substances and their refractive indexes; studied terpene and its derivatives (1880); the refractivity of benzol (1894) and of tautomeric substances (1899). His work supported Kekulé's formula for benzene. Developed apparatus for fractional distillation in vacuum. He introduced physical chemical methods into organic chemistry and gave the names "enol" and "keto" to the two forms of acetoacetic ester.

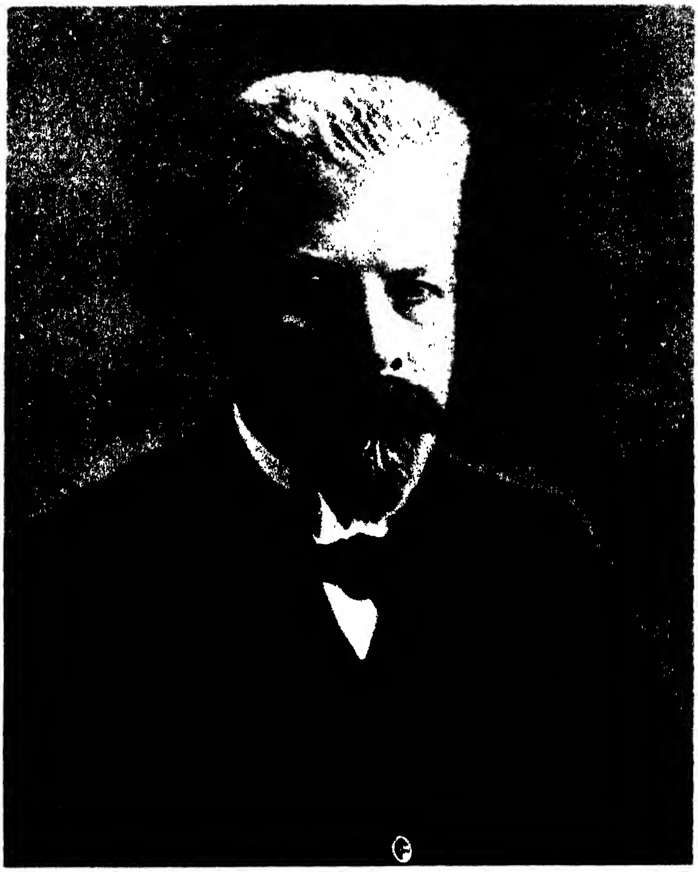


HEINRICH von BRUNCK: 1847–1911.

German industrial leader, connected with the Badische Anilin and Soda-Fabrik 1869–1911. He was responsible for the industrial production of anthraquinone, alizarin, and the development of synthetic indigo by his company which involved the expenditure of six million marks and years of experimental work. He was also responsible for the development of the contact process in the manufacture of sulfuric acid, the production of electrolytic chlorine, and of the Birkeland and Eyde's, Schönherr's, and Haber's processes for the fixation of nitrogen. He organized the world famous "I. G. Farbenindustrie A-G."

CORNELIS ADRIAAN LOBRY DE BRUYN: 1857–1904.

Professor at Amsterdam. His work was in the field of organic chemistry and included the reactions of the di-nitro compounds; the action of alcohols as solvents, which study led to the isolation of free hydroxylamine and hydrazine; the action of ammonia on the carbohydrates which gave a new class of compounds, the "osamines," described by Fischer "as the bridge between the sugars and the proteins."



EDUARD BUCHNER: 1860–1917.

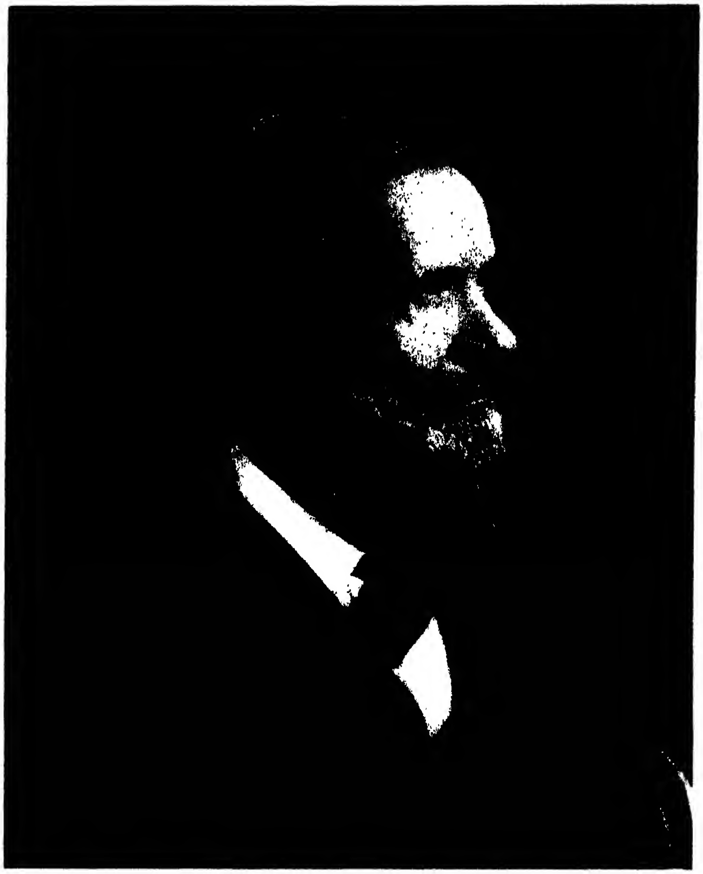
Professor at Tübingen (1896), Berlin Agricultural College (1898), Breslau (1909) and Würzburg (1911). Although he did much work in organic chemistry synthesizing di-iodo-acetamid (1888) and isolating pyrozole (1889) he will be known for his fundamental investigations in the field of fermentation. His first report (1897) on the subject was epoch-making and showed that alcoholic fermentation could proceed without the presence of yeast cells. He discovered the action of enzymes and isolated zymase (1897). Then followed investigations in the general field of enzyme action with the discovery of the production of other alcohols and acids by means of ferments. These discoveries have developed into large industrial applications. Received the Nobel Prize (1907).

ROBERT WILHELM BUNSEN: 1811–1899.

Professor at Marburg (1838), and Heidelberg (1852–1889). A great scientist and an inspiring teacher. His work on cacodyl (1837–1842) gave a great impetus to the study of organic radicals. Conducted, with Roscoe, extended investigations on the measurements of light intensities and developed a normal light unit (1857). Developed methods of gas analysis, iodimetry (1853), spectrum analysis (1859), and flame tests. With Kirchhoff he invented the spectroscope, with which he later discovered rubidium and cesium (1860). Isolated lithium (1865). Designed the ice calorimeter, gas burner, battery, filter pump, and photometer, all known by his name.

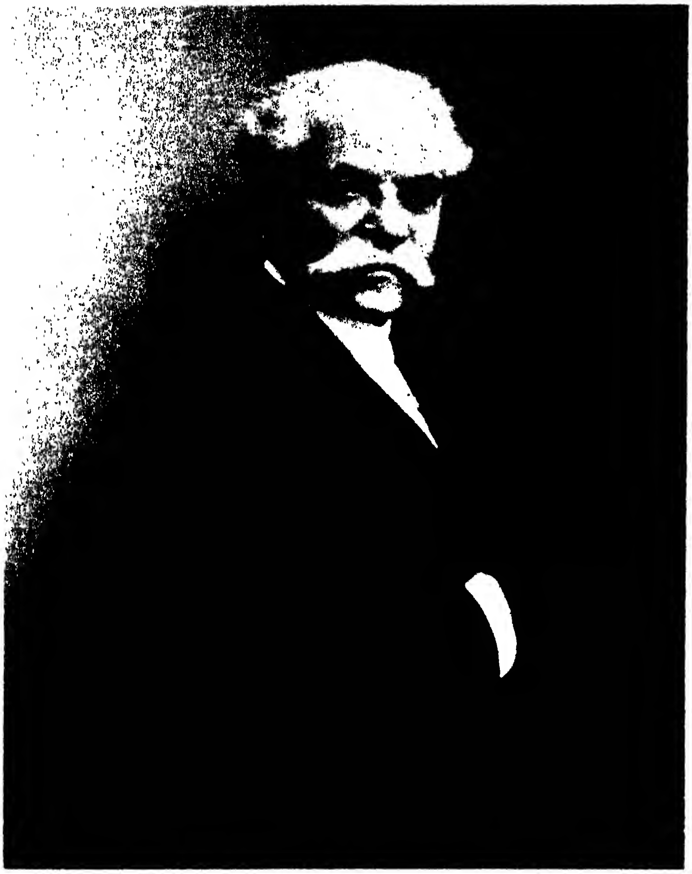
AUGUSTE THOMAS CAHOURS: 1813–1891.

French chemist. Professor at the École Polytechnique and Master of the Mint. Pupil of Chevreul. His investigations were largely in organic chemistry. Discovered amyl alcohol (1837), anisol (1841), methyl salicylate (1843), allyl alcohol (1856), phellandrene (1841), tin tetraethyl (1860). Studied cuminol, sulfonium bases, butyl and propyl compounds of tin, and prepared acid chlorides by the action of phosphorus pentachloride (1846).



STANISLAO CANNIZZARO: 1826–1910.

One of Italy's outstanding scientists. Professor at Genoa, Palermo, and Rome. Studied with Chevreul. Although known for his work on cyanamide and the aromatic aldehydes, his fame rests on the fact that he brought to the attention of the chemical world the hypothesis of Avogadro which had lain forgotten since 1811. At the famous "Congress of Chemists" held at Karlsruhe (1860), Cannizzaro spoke on this hypothesis and distributed a paper in which he threw light on the conception of the atom and the molecule and evoked a clear understanding of atomic and molecular weights out of the large mass of data which had been accumulating since the time of Lavoisier.



HEINRICH CARO: 1834–1910.

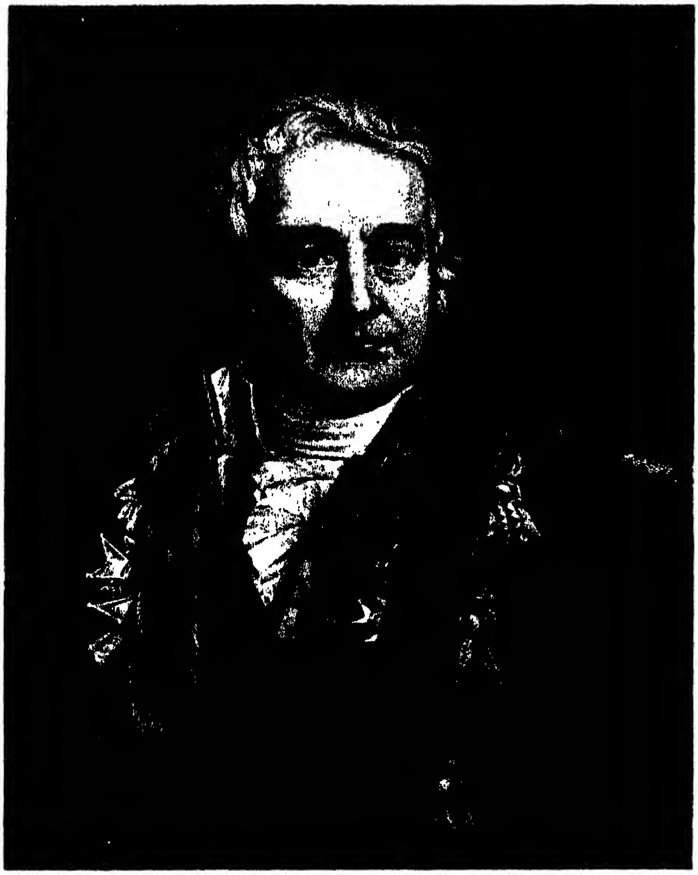
One of the founders of the coal-tar dye industry both in England and Germany. His discoveries include the induline dyes (1865), Bismarck brown (1867), acridine synthesis (1871), eosine (1874), fuchsine, methylene blue (1877), Caro's acid, $H_2S_2O_5$ (1898) and the reduction of nitro-benzene by tin and hydrochloric acid. His work on the diazo compounds laid the foundations for the azo-dye industry. His English patents for alizarin preceded those of Perkin by one day. He was one of the organizers and developers of the great "Badische Anilin und Soda-Fabrik" at Mannheim.

HENRY CAVENDISH: 1731–1810.

Established the elementary nature of hydrogen (1766); the composition of water (1784); synthesized nitric acid (1784); showed air to be a mixture of constant composition (1785) and suspected the presence of another gas (argon) in the air. Although a man of great wealth and social position he lived a recluse, shunning all publicity and devoting himself to his scientific studies. There is only one sketch of Cavendish in existence, as above, preserved in the British Museum, and this was made by the artist Alexander when Cavendish was unaware of his presence. The Cavendish Laboratory in Cambridge commemorates the accomplishments of this remarkable man.

"Upon all subjects he was luminous and profound" — "His name will be an immortal honor to his house, his age and to his country." — *Davy.*

"He was the richest of the learned and the most learned of the rich." — *Biot.*



JEAN ANTOINE CHAPTAL, COMTE DE CHANTELOUP: 1756–1832.

Professor at Montpellier and Minister of the Interior under Napoleon. Established works for the manufacture of acids, alum and soda; introduced the metric system into France. He applied chemistry to industry and agriculture and did much to develop France industrially. His treatise on Applied Chemistry was widely translated. President Washington invited him repeatedly to come to America and help in developing this country's resources.

MICHEL EUGÈNE CHEVREUL: 1786–1889.

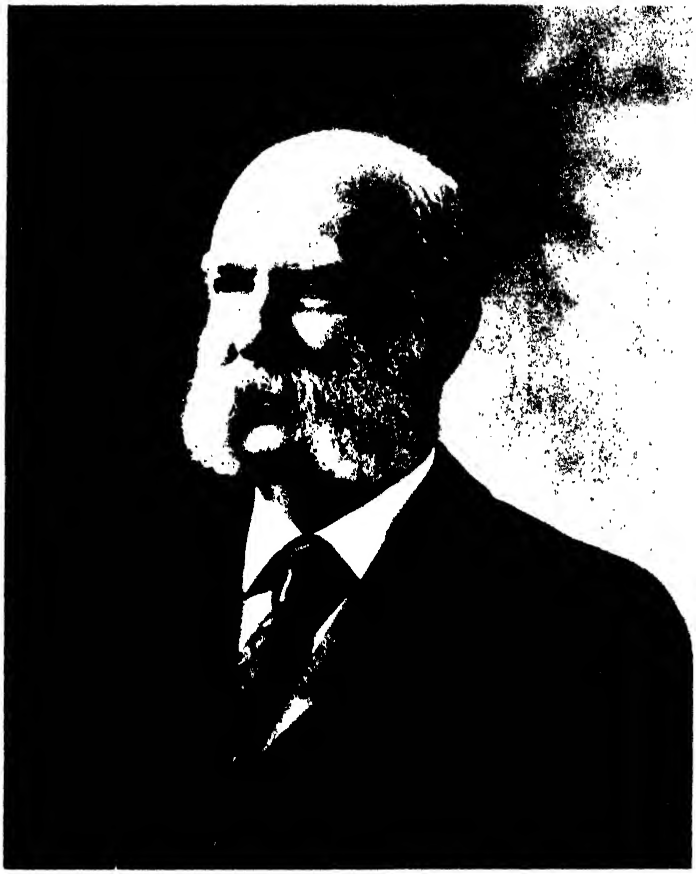
Born at Angers; studied at Paris; Professor at the Lycée Charlemagne; succeeded Vauquelin at the Natural History Museum; director of the dyeing department of the Gobelin tapestry works. His researches in the field of fats (1823), in which he showed them to be esters of glycerol, are classic. He discovered and named stearic and oleic acids. On his hundredth birthday he received the homage of the entire scientific world. He died at the age of one hundred and three.

GIACOMO CIAMICIAN: 1857–1922.

Professor at Padua (1887) and Bologna (1889). Studied pyrrol, pyrroline and plant alkaloids. Investigated the chemical action of light in inducing the oxidation and reduction of aldehydes and ketones, and the action of chemical compounds on the development of plants.

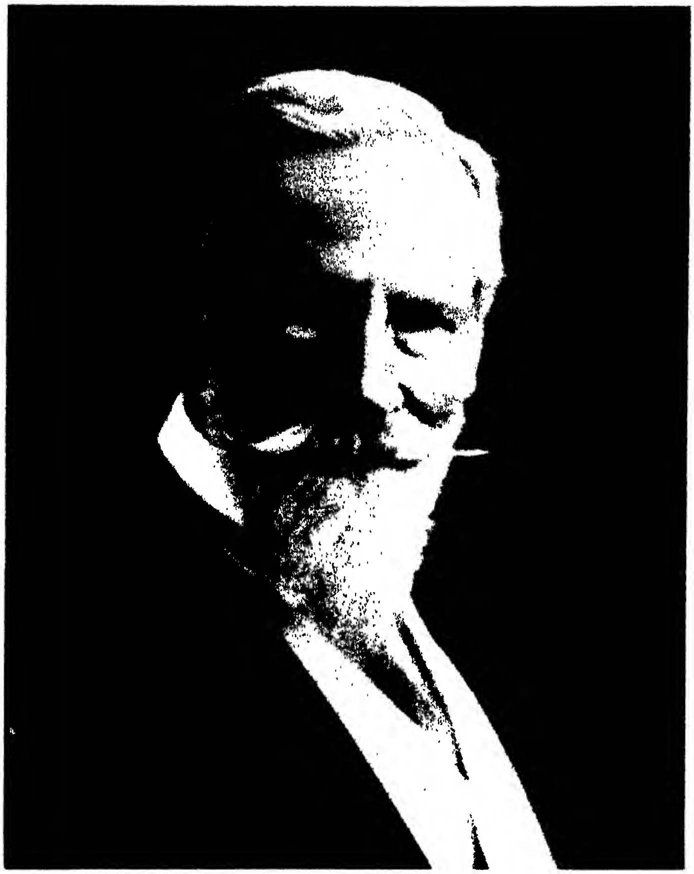
PER THEODOR CLEVE: 1840–1905.

Pupil of Wurtz. Professor at Upsala. Worked on the complex ammoniacal-platinum compounds and discovered isomers of the same (1874). His most important work was on the rare earths. He showed the tetravalence of thorium and the properties of cerium, lanthanium, and erbium. Predicted that didymium might contain another element which was later discovered by Welsbach (1885) and known as neodymium. He succeeded in splitting erbia into three constituents, erbia, holmia, and thulia. Holmium he named for his native city Stockholm and Thulium for Scandinavia. The mineral cleveite is named for him. Received the Davy Medal (1894).



JAMES MASON CRAFTS: 1839–1917.

Born in Boston; graduate of Harvard; studied with Plattner, Bunsen, and Wurtz. He resided in Paris from 1874 to 1891 where he carried on his researches, which included the densities of the halogens and organic compounds of silicon. He was a co-discoverer of the important Friedel-Crafts reaction. On his return to the United States he became Professor of Organic Chemistry at the Massachusetts Institute of Technology (1892–1897) and later President of the Institute (1897–1900). Awarded the Rumford Medal, 1911.



SIR WILLIAM CROOKES: 1832–1919.

Private investigator. Founder and editor of *Chemical News* (1859–1919). Discovered thallium (1861) by aid of the spectroscope and determined its atomic weight. Identified the helium discovered by Ramsay (1895) in cleveite as identical with that discovered by Lockyer in the sun (1868). Studied radiation and devised the radiometer (1874). His investigations on the electric discharge in rarified gases led to his development of the Crookes' tube which led to the discovery of cathode rays and the belief that a new form of matter existed in the cathode discharge. Announced the discovery of Uranium X (1900) and devised the spinthariscope (1903). Developed the form of glass used by steel and glass workers to protect their eyes from the dangerous ultraviolet rays. Developed views on the origin of the elements from a primary substance termed "protyle" (1886). In his latter years he became interested in spiritualism and entertained mediums in his household in an endeavor to penetrate the realms of the unknown. Received the Royal, Davy, and Copley Medals.

SIR WILLIAM CROOKES.

Caricature by "Spy," Sir Leslie Wood, entitled "Ubi Crookes ibi lux," which appeared in *Vanity Fair* as a colored supplement May 21, 1903.

MADAME MARIE SKLODOWSKA CURIE: 1867–1934.

A Pole by birth, wife of an eminent French physicist, her life and work were centered in Paris. Following the discovery of the effect of uranium compounds on the photographic plate by Becquerel, Madame Curie started her search for the cause of this phenomenon. Discovered that thorium was also radioactive. Showed that radioactivity was proportional to the quantity of uranium in the substance under examination. Discovered that the activity of pitchblende was stronger than the quantity of uranium present would warrant and concluded that a new element must be present in the ore. In 1898 her husband joined her in her search for this new element. In July announced the discovery of a new element which she named *polonium* for her native country. On December 26, 1898 announced that another element was present to which they gave the name *radium*. From 1898 to 1902 they worked in a crude shed with few facilities, extracting and concentrating the fractions from tons of pitchblende. On the death of her husband, who was killed by an auto-truck (1906), she was given his chair in Physics and became the first woman to occupy a professorship in the Sorbonne. In 1910 Madame Curie and Debierne succeeded in isolating radium metal by electrolyzing the chloride with a mercury cathode and distilling off the mercury. In 1921 she visited America and was presented with a gram of radium salt by the women of the United States. In 1903 received the Nobel Prize with her husband and Becquerel. In 1911 received the Nobel Prize for a second time for the isolation of the radium metal.

MONSIEUR AND MADAME CURIE.

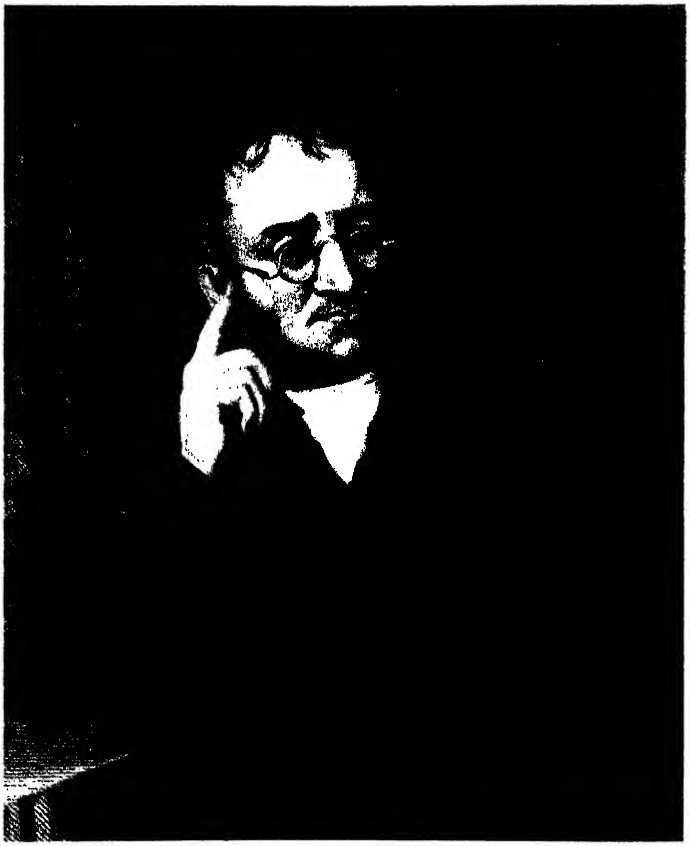
Caricature by "Imp," entitled "Radium," appearing in *Vanity Fair* as a colored supplement December 22, 1904.

THEODOR CURTIUS: 1857-1928.

Professor at Kiel and successor to Victor Meyer at Heidelberg (1898). His researches were largely with compounds of nitrogen and the diazo derivatives of the fatty acids. He discovered hydrazine in 1889 and hydrazoic acid in 1890.

LOUIS JACQUES MANDÉ DAGUERRE: 1789–1851.

French painter and physicist. Developed with Nièpce the art of photographing on metal. Both men started their investigations independently but joined forces in 1829. Nièpce died in 1833 before the completion of the investigation. The discovery of the process of making daguerreotypes was announced in 1839. The time of exposure for a landscape was seven to eight hours "but single monuments when strongly lighted or which are of themselves very bright can be taken in about three hours." A museum with the original cameras of Nièpce and Daguerre is located at Chalon-sur-Saône.



JOHN DALTON: 1766–1844.

A Quaker schoolteacher of Manchester, England. He formulated the Law of Partial Pressures and from his study of the composition of the oxides of carbon and the gases, methane and ethylene, he announced the Laws of Definite and Multiple Proportions. This work led to his formulation of the Atomic Theory (1807). In 1808 he published his "New System of Chemical Philosophy" based on his conception of the atoms as the units of all matter both elementary and compound. He developed a system of chemical symbols and prepared a table giving the relative weights of the atoms of a list of elements. He lived to see his theories accepted by the chemical world.

JOHN DALTON COLLECTING "FIRE MARSH GAS"

A mural painting in the Town Hall, Manchester, England.

JEAN DARCET: 1725–1801.

Professor at the Collège de France. Director of the Sèrves Porcelain Factory and the Gobelins Tapestry Works. Assayer of the Mint. Improved the manufacture of porcelain, soap, salt and the extraction of gelatine from bones. Produced an alloy of low fusing-point similar to Wood's metal. He applied his chemistry to the improvement of industry.

JEAN PIERRE JOSEPH DARCET: 1777-1844.

Assayer of the French Mint. Developed methods for the separation of gold from other metals (1802). In public positions he aided greatly in developing the chemical industries of France and centering attention upon the importance of sanitary chemistry to the public health.

SIR HUMPHRY DAVY: 1778–1829.

Brilliant English scientist and pioneer in the study of the chemical action of the electric current. He discovered the physiological action of nitrous oxide (1794); invented the miner's safety lamp (1815); showed that chlorine (1810) and iodine (1813) are simple substances; isolated sodium and potassium in 1807; boron in 1808; and later prepared barium, calcium, strontium, and magnesium in the metallic state. He wrote to his mother, "I devote every moment to labors which I hope will not be wholly ineffectual in benefiting society, and which will not be wholly inglorious for my country hereafter; and the feeling of this is the reward which will continue to keep me employed." Knighted by the Prince Regent (1812). Worked principally at the Royal Institution, where his public lectures were famous.

CONTEMPORANEOUS CARICATURE OF A LECTURE
AT THE ROYAL INSTITUTION
IN 1802

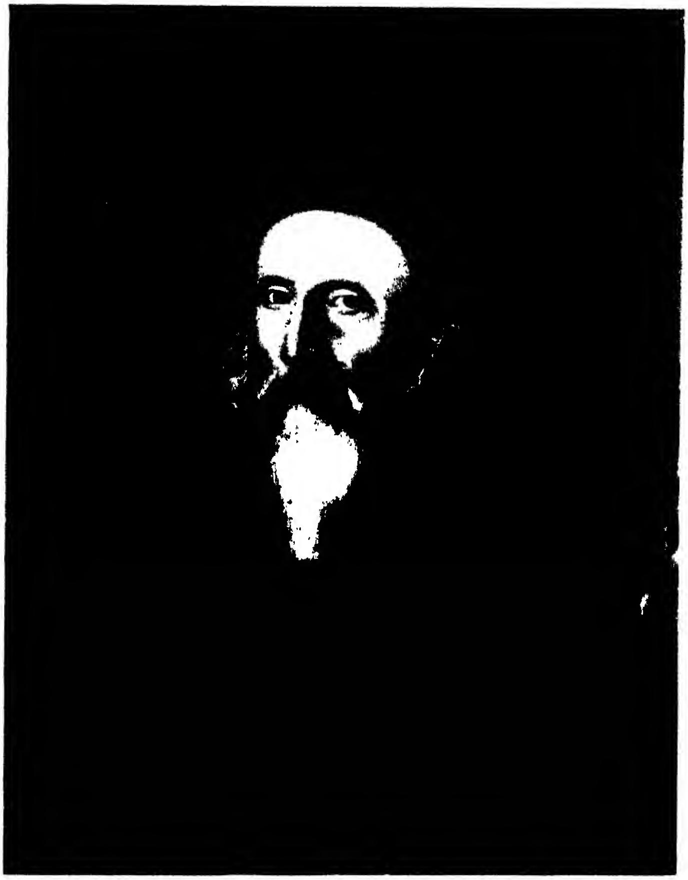
Sir J. C. Hippesley, the subject, is embarrassed by the administration of too much laughing gas by Dr. Garnett, to the delight of Humphry Davy who holds the bellows. Count Rumford, the founder of the Royal Institution, is seen standing at the right of the lecture table with a medal on his coat. Others in the group have been identified.

HENRY DEACON: 1822–1876.

Apprenticed at the age of fourteen to an engineering firm he became one of England's leaders in industrial chemistry. He is best known for his process for producing chlorine by passing hydrochloric acid gas and air over copper salts (1868); this process is known by his name. He held many patents mostly relating to the manufacture of heavy chemicals.

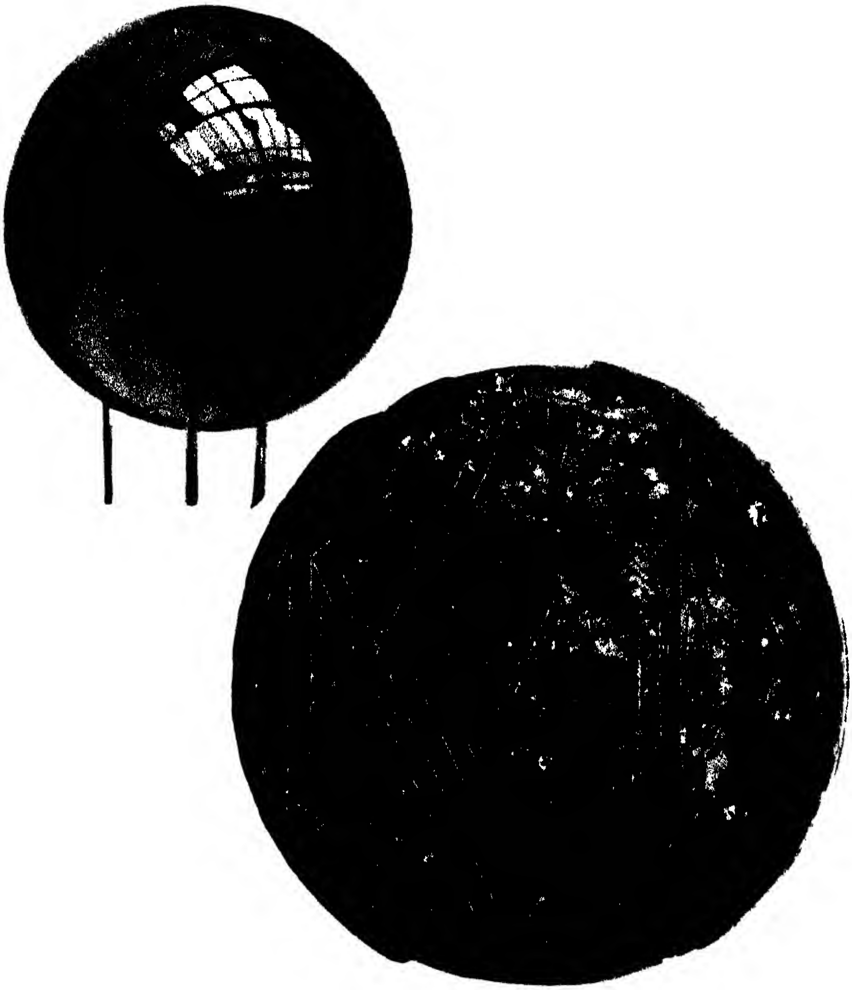
HENRI JULES DEBRAY: 1827–1888.

Professor at the Sorbonne (1881) as successor of Deville. Assayer of the Mint. Studied the decomposition of the oxides and gaseous dissociation on the carbonates of copper and the alkaline earths. With Deville he worked on the metals of the platinum group and prepared the acids of ruthenium (1888) and a method for the separation of rhodium. Studied the salts of beryllium, molybdenum, tungsten, and cerium. He had the honor of reporting Moissan's isolation of fluorine to the Academy.



JOHN DEE: 1527–1608.

A brilliant English scholar and conscientious believer in astrology, alchemy, crystal-gazing and clairvoyancy. He possessed a glass crystal by means of which through a medium he could hold conversations with the "blessed angels of God." In need of a medium for this purpose he came under the power of Edward Kelley, who duped Dee through a long period of years. He named a lucky day for Elizabeth's coronation and she was his friend and patron through life. From 1583 to 1589 Dee and Kelley were active in the courts of Poland and at the court of Rudolph II in Prague where they "produced gold from mercury" and where they gave a séance for Rudolph with the crystal. He returned to England (1589) at Elizabeth's request and was given the Chancellorship of St. Paul's Cathedral and later was made the Warden of Manchester College. Dee's crystal and the wax seal on which it was placed during a séance are to be seen at the British Museum.



JOHN DEE'S CRYSTAL AND WAX SEAL.

Dee's crystal resting on three pins, and the wax seal on which it was placed during a séance are still preserved in the British Museum. Perhaps the reader by sufficient concentration may be able to see Dee and Kelley gathered around the crystal while Queen Elizabeth or Rudolph II in the background eagerly awaits some words from the "blessed angels of God." Do not be confused by the reflection of a Museum window in the crystal.

RUDOLPH II VISITS THE LABORATORY OF HIS ALCHEMIST

A painting by Brozik in the New York Public Library

Rudolph II (1522–1612), Emperor of the Holy Roman Empire, was an ardent believer in astrology, alchemy and magic. He maintained at his court in Prague a great following of charlatans and impostors as well as true scholars such as Tycho Brahe and Kepler. Those who claimed knowledge of the Philosopher's Stone, the Elixir of Life, of celestial signs, potable gold and tincture of pearls were rapidly advanced in his confidence. Among those at his court were John Dee, the scholar, and Edward Kelley, the impostor, who duped both Dee and Rudolph. This picture by Brozik shows Dee presenting to the Emperor a crucible containing a nugget of synthetic gold. Kelley is the figure in the background with a wide hat. Some of the lead that Rudolph tried to change to gold is still preserved in Vienna.

STREET OF THE GOLDMAKERS, PRAGUE.

In this small street under his castle, Emperor Rudolph II (1552–1612) housed his alchemists and in some of these houses may still be seen the original forges where his alchemists endeavored to transmute lead and where Rudolph is reputed to have worked. In this street once dwelt Daniel Prandtner, Christopher von Hirschberg, Bawor Rodowsky von Hustrian, Salomena Scheinpflug, all of doubtful reputations. The Court Director of the Alchemists, Dr. von Hayek, had to be ever on the alert to detect frauds by false bottoms to the crucibles, hollow stirring rods containing gold filings, gold leaf hidden in charcoal, or charcoal soaked in gold solution! Here too dwelt Rudolph's gold and silversmiths, cameo-cutters, and illuminators, and here dwelt those famous figures *John Dee* and *Sir Edward Kelley, the Golden Knight.*

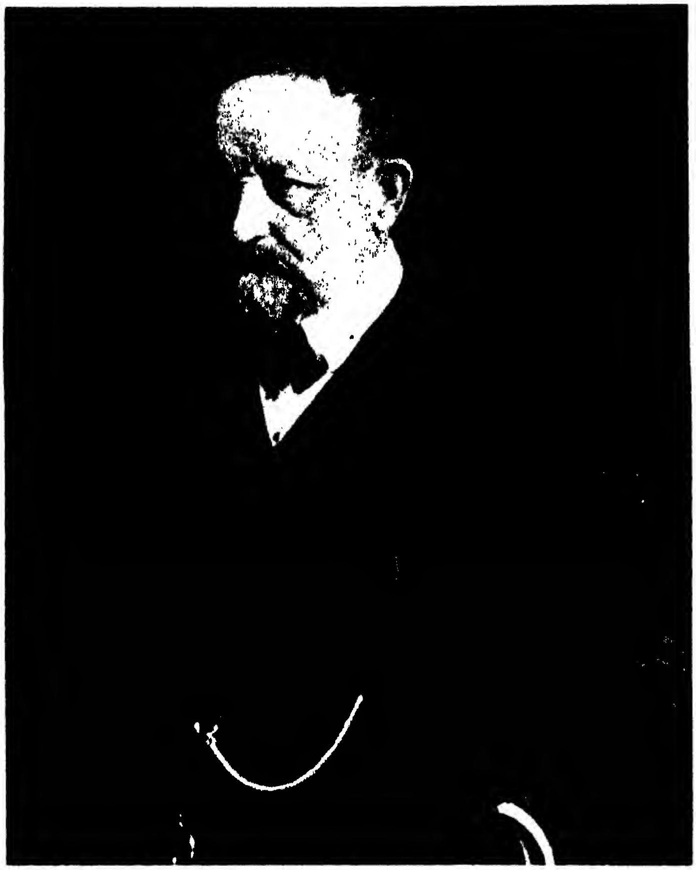
Courtesy of T. L. Davis

THE DIVINE METAMORPHOSIS.

Alchemy flourished in Bohemia during the sixteenth and seventeenth centuries and reports of successful transmutation of base metal to gold were common. Ferdinand III brought to his court in Prague the alchemist von Richthausen who in the presence of Ferdinand caused such a quantity of mercury to be changed to gold that the emperor had this medal cast from it, valued at 300 ducats ($600 ca.). The inscriptions on the medal read:

(Obverse)
Divine Metamorphosis
Exhibited at Prague
15 January in the year 1648
in the presence of the Holy Emperor
His Majesty Ferdinand III

(Reverse)
As this is the art
of but few men, so is it practiced
but rarely. Praised be God in Eternity
who communicates this part of his
infinite power to us his most
abject creatures.



MAX DELBRÜCK: 1850–1919.

One of Germany's great industrial organizers. For forty-five years he was associated with the fermentation industry. During this time he founded a school for distillation workers, a glass factory for producing reliable apparatus and instruments, and an experimental distillery. He established the "Zeitschrift für Spiritus-Industrie" and the "Wochenschrift für Brauerei" and schools and laboratories for the study of potato and hop culture. He applied scientific studies to all the questions of fermentation, including the production of pure cultures and the action of enzymes.

EUGÈNE ANATOLE DEMARÇAY: 1852–1904.

Studied with Wurtz, Dumas, and Deville. Assistant to Cahours. Carried on his researches in his private laboratory. His early work was in organic chemistry with the essences and ethers of unsaturated acids (1878). Investigated the volatility of metals at low temperatures and pressures. Constructed a highly efficient machine for compressing gases for the production of low temperatures on expansion. He was also known for his spectroscopic work and for his method of fractional crystallization of the rare earths from aqueous solution. Discovered europium (1896) and gave spectroscopic proof of radium for the Curies.

HENRI SAINTE-CLAIRE DEVILLE: 1818–1881.

Professor at the Sorbonne, as successor of Dumas (1859). Investigated the halides of boron and silicon. Devised methods for the purification of the platinum group metals and a furnace for their fusion (1852). Studied gaseous dissociation and was first to use the term "dissociation." Isolated terpineol (1849) and nitrogen pentoxide (1849). He was first to obtain metallic aluminum on a large scale by the action of sodium on aluminum chloride and exhibited ingots of the metal at the Paris Exposition (1855). He also produced magnesium and silicon in quantity; showed the catalytic property of platinum and synthesized many minerals.

HENRY SAINTE-CLAIRE DEVILLE AND HIS COLLEAGUES

A mural painting in the École Normale Supérieur, Paris.

Debray (1827–1888)

Deville (1818–1881)

Ditte (1843–1908)

Troost (1825–1911)

Hautefeuille (1836–1902)

The scene shows Hautefeuille carrying out an experiment on dissociation while Deville lectures. The minerals synthesized by Deville and his associates and the metals aluminum, magnesium and silicon prepared by Deville are exhibited on the lecture table.

SIR JAMES DEWAR: 1842–1923.

Pupil of Playfair and Kekulé. Professor at the Royal Institution. Determined the formula for quinoline (1871) and the effect of pressure and temperature on the lines of the emissions spectra. Liquefied oxygen in quantity (1891) and obtained liquid hydrogen (1898) and solid hydrogen (1899) and determined its melting and boiling points. In conjunction with Moissan he liquefied fluorine. Developed the use of carbon for gas adsorption and the production of high vacua (1905). For the preservation of low boiling liquids he developed the "Dewar flask," now found in every workingman's lunchbox and known as a thermos bottle. Received the Rumford Medal (1894). Knighted (1904).

JOHANN WOLFGANG DOEBEREINER: 1780–1849.

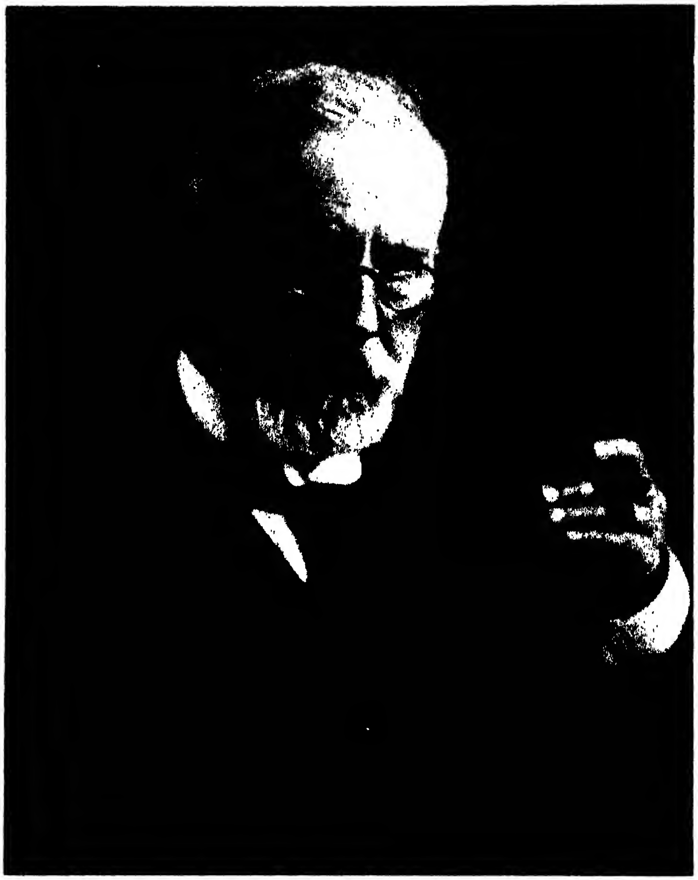
Professor at Jena (1810–1849). First to note the relationship between the atomic weights of the elements calcium, strontium and barium (1817) and later showed that other groups or "triads" of the elements existed. He may also be regarded as the first person to recognize the catalytic effect of platinum (1823); oxidized sulphur dioxide to the trioxide by means of platinum (1832) and showed the adsorption of oxygen by platinum sponge (1834). The "Doebereiner lamp" is a well-known example of the catalytic action of platinum. Prepared furfural (1831) and aldehyde ammonia (1831). The quick vinegar process is the outgrowth of Doebereiner's studies of the relation between alcohol and acetic acid (1832).

PIERRE LOUIS DULONG: 1785–1838.

Assistant to Berthollet and later Professor of Physics at the École Polytechnique. Discovered the chloride of nitrogen (1811) and lost an eye and several fingers during his investigation of the compound. Studied the oxides of phosphorus and nitrogen. In 1819 in conjunction with Petit (1791–1820) he announced the relation of specific heats to atomic weights.

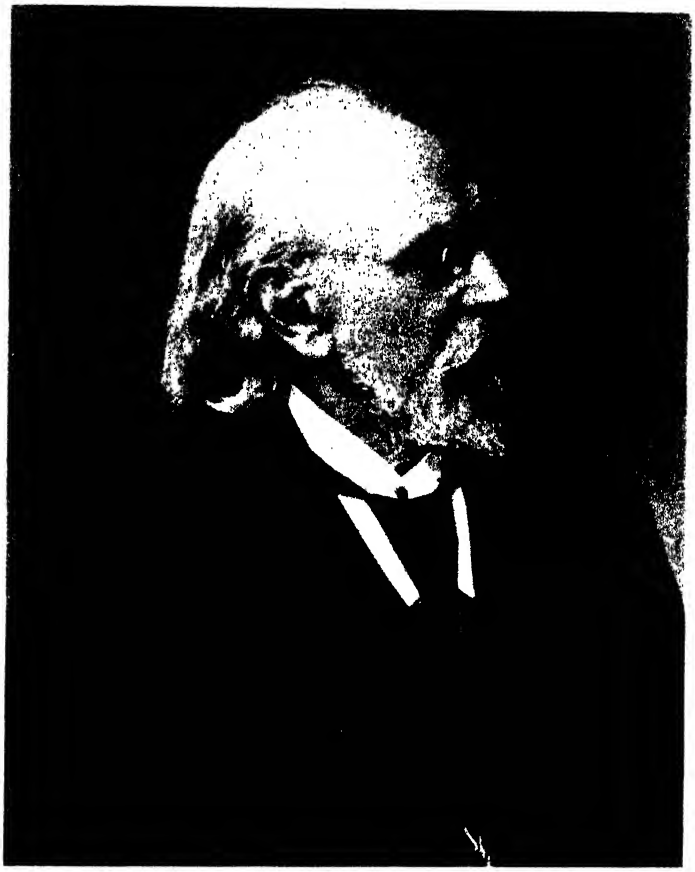
JEAN BAPTISTE ANDRE DUMAS: 1800–1884.

A skillful experimentalist and inspired teacher of chemistry at the Sorbonne. One of the greatest of French chemists. He devised methods for the determination of nitrogen in organic substances and a method for the determination of vapor densities. His studies on the substitution of chlorine in place of the hydrogen of organic molecules were of the greatest importance in the development of the type theory of organic structure. This study of the substitution of chlorine for hydrogen was precipitated by suffocating fumes developing at a soirée at the Tuileries from the candles which had been bleached with chlorine.



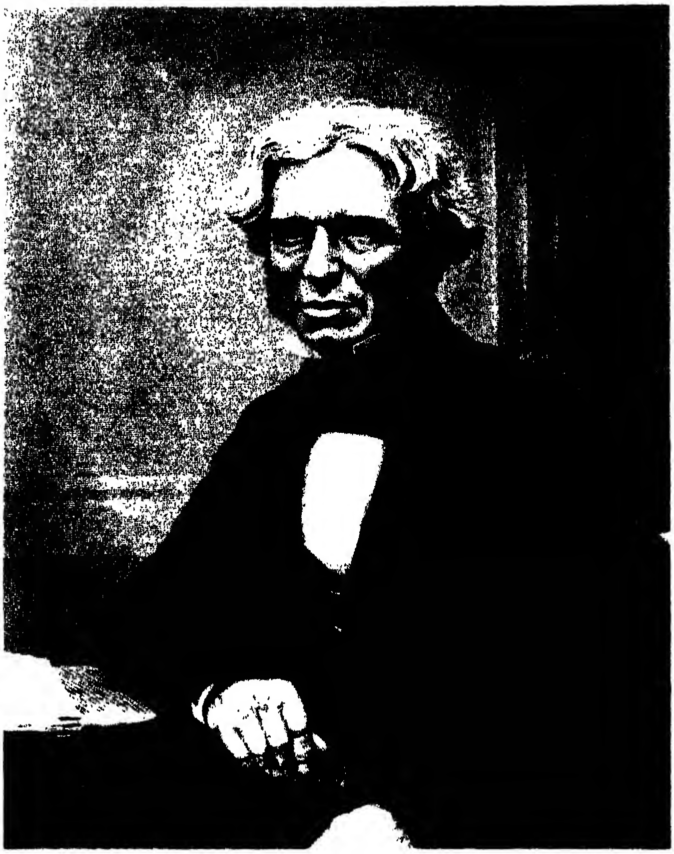
PAUL EHRLICH: 1854–1915.

Director of the Institute for Experimental Therapy, Frankfurt. Ehrlich bridged the sciences of Chemistry, Biology and Medicine; founded Chemotherapy, developed methods of identification of pathological processes by chemical reagents, prepared antitoxins and formulated a theory of serum therapy. His crowning achievement (1910) was when by substituting arsenic for an azo group he was able to prepare p, p-dioxy-m, m-diamino arseno benzene, known as "Salvarsan" or "606" which was found to be a specific for syphilis. A celebration planned in his honor for his eightieth birthday was forbidden due to his Jewish parentage. Received the Nobel Prize in 1908.



EMIL ERLENMEYER: 1825–1909.

Professor at Heidelberg (1863), Munich (1868–1883). His life bridged the old chemistry of "types" to that of valence and structure. His observations on the atom, molecule, and saturation were fundamental in developing the newer ideas of valence. His work lay mostly in the constitution of aliphatic compounds; he changed glycerine to isopropyl alcohol, synthesized isobutyric acid and showed mannite to be a straight chain compound. Introduced the names "hydroxyl" and "structural chemistry." Explained the dissociation of ammonium chloride at high temperatures, the splitting of secondary and tertiary alcohols, and studied leucine and tyrosine and their derivatives. What chemist is not grateful for the Erlenmeyer flask!



MICHAEL FARADAY: 1791–1867.

One of the greatest experimentalists who ever lived. He was a bookbinder until the age of twenty-one and had educated himself by reading the books that were given him for binding. He thus became interested in science and applied to Sir Humphry Davy for employment at the Royal Institution. He became Davy's assistant in 1817 and his successor as head of the Royal Institution in 1825. Although he is best known for his researches on electricity and magnetism he also made important contributions to chemistry. He formulated the laws of electrolysis which bear his name. He discovered benzene (1825), two chlorides of carbon, liquefied chlorine and carbon dioxide, and worked with isomeric and polymeric hydrocarbons. "My best discovery was Michael Faraday." — Davy.

FARADAY GIVING HIS CARD TO FATHER THAMES.

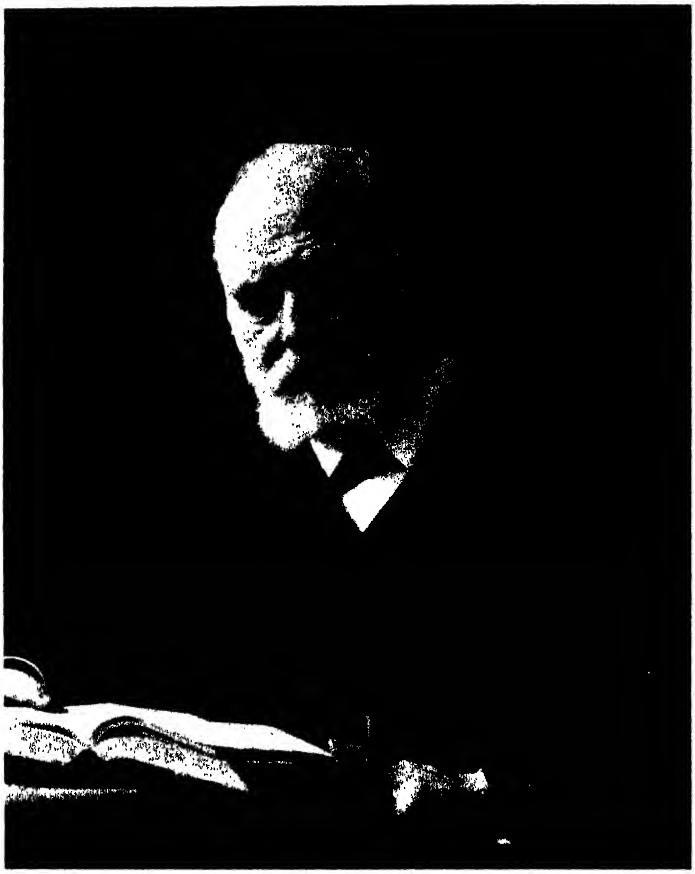
Contemporaneous cartoon from *Punch* on Faraday's appointment to the Commission for Improving the Unsanitary Condition of the River Thames.

HERMAN von FEHLING: 1812–1885.

Professor at Stuttgart for forty years; pupil of Gmelin and friend of Kopp. Worked on the fatty acids from palm-oil; isolated succinimide, discovered benzonitrile (1844), and gave the name "Nitrile" to this class of compounds. Showed the polymerization of aldehyde to paraldehyde (1838). Edited the famous "Neues Handwörterbuch der Chemie" from 1871 till his death. His name is known to all medical students for his method of determination of sugar in the urine by the reduction of ammoniacal copper sulfate solution, known as "Fehling's solution" (1849).

EMIL FISCHER: 1852–1919.

A student of Baeyer and successor of Hofmann at Berlin. His researches were the first to illuminate the structure of the sugars, the polypeptides, the purines and the constitution and synthesis of the tannins. He is generally regarded as the greatest organic chemist of his time. Received the Nobel Prize (1902) for his synthetic work in the sugar and purine groups of substances.

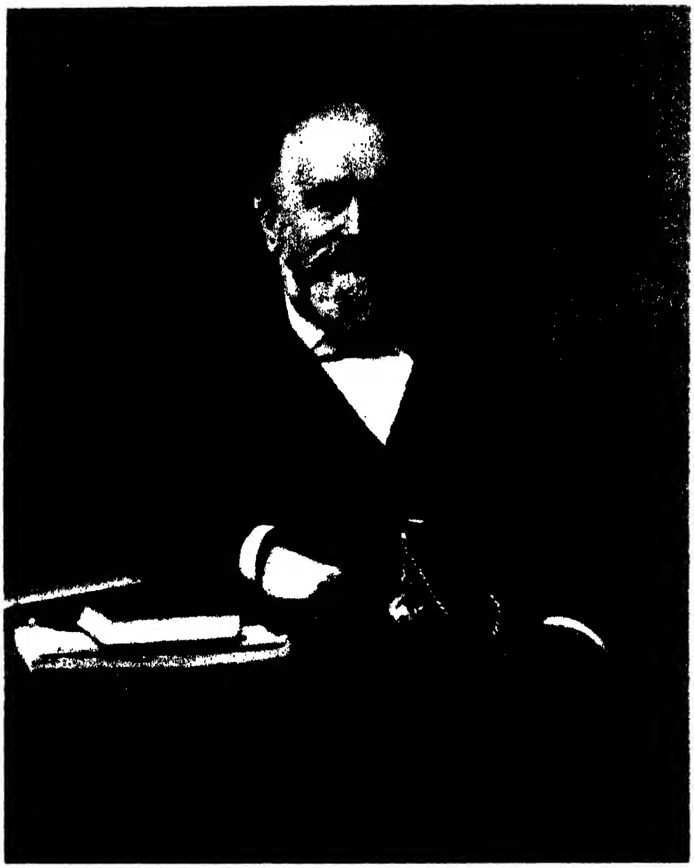


RUDOLF FITTIG: 1835–1910.

Professor at Göttingen (1863), Tübingen (1870), Strassburg (1876). Synthesis of xylol and its constitution; constitution of phenanthrene (1873); discovered the pinacone reaction (1858); action of sodium on mixed alkyl halides (1863); synthesis of mesitylene (1868); reduction of ketonic esters by zinc dust (1887); coumarone and the constitution of the lactones. Author of "Grundriss der organischen Chemie" (six editions and widely translated) and "Grundriss der anorganischen Chemie." He lived through a period which was rich in the development of organic chemistry and was one of its chief founders. Received the Davy Medal (1895).

ANTONINE FRANÇOIS DE FOURCROY: 1755–1809.

Professor at the "Jardin des Plantes." His work was in physiological chemistry and public health. Founded with Lavoisier, Berthollet and Morveau the "Annales de Chemie" and collaborated with them in developing the systematic nomenclature of chemistry. His spirited lectures and writings aided in establishing the antiphlogistic theory, and the enthusiasm which he aroused in his students contributed to make chemistry in France so fruitful during the succeeding generation. From poor and humble birth he became Minister of Education under Napoleon, who made him a Count of the Empire. Fourcroy died this same day.



SIR EDWARD FRANKLAND: 1825–1899.

Professor at the Royal Institution (1863) as successor of Faraday and at the Royal College (1865) as successor of Hofmann. Pupil of Bunsen and Kolbe. He discovered the organo-metallic compounds $Sn(C_2H_5)_4$, $Hg(CH_3)I$; synthesized hydrocarbons by the zinc alkyl reaction (1849); studied the constitution and reactions of acetoacetic ester (1864). Did much to bridge the transition from the type theory to that of valence and gave expression to the modern idea of valence (1852). Recognized that nitrogen was trivalent and pentavalent. Associated with Lockyer in the discovery of helium in the sun. Received the Royal Medal (1857) and the Copley Medal (1895).

KARL REMIGIUS FRESENIUS: 1818–1897.

An assistant to Liebig. He later founded (1848) a laboratory and school of analytical chemistry at Wiesbaden. He devoted his whole life to perfecting the methods of chemical analysis. For many decades his books upon this subject were considered the standard authority throughout the world. Founded the "Zeitschrift für analytische Chemie."

CHARLES FRIEDEL: 1832–1899.

Most distinguished pupil of Wurtz and his successor at the Sorbonne (1884). His work on the ketones (1862), the constitution of pinacone and lactic acid, the synthesis of glycerol and the action of aluminum chloride in the synthesis of aromatic condensation products, called the Friedel-Crafts reaction (1877), made his name known in organic chemistry. In his studies of silicon he prepared a series of esters of silicic acid and showed the analogy of the compounds of silicon and carbon and thus confirmed the atomic weight of silicon. Determined the vapor densities and molecular weights of the chlorides of aluminum, iron, and gallium and showed them to be Al_2Cl_6, Fe_2Cl_6, Ga_2Cl_6. Synthesized minerals by aid of high temperatures and pressures and thus showed the genealogy of many rocks. Studied the pyroelectric behavior of crystals. Received the Davy Medal in 1880.

CARL FRIEDHEIM: 1858–1909.

Professor at Bern. As a pupil of Rammelsberg and later as his assistant, his interests became centered in inorganic and analytical chemistry. He studied the complex phosphomolybdic and tungstic acids; the determination of vanadium, arsenic, molybdenum and chromium; the separation of chlorine, bromine and iodine and the use of hydrogen peroxide and hydroxylamine in analysis. Edited the seventh edition of Gmelin-Kraut's "Handbuch der anorganischen Chemie."

PAUL FRIEDLÄNDER: 1857–1923.

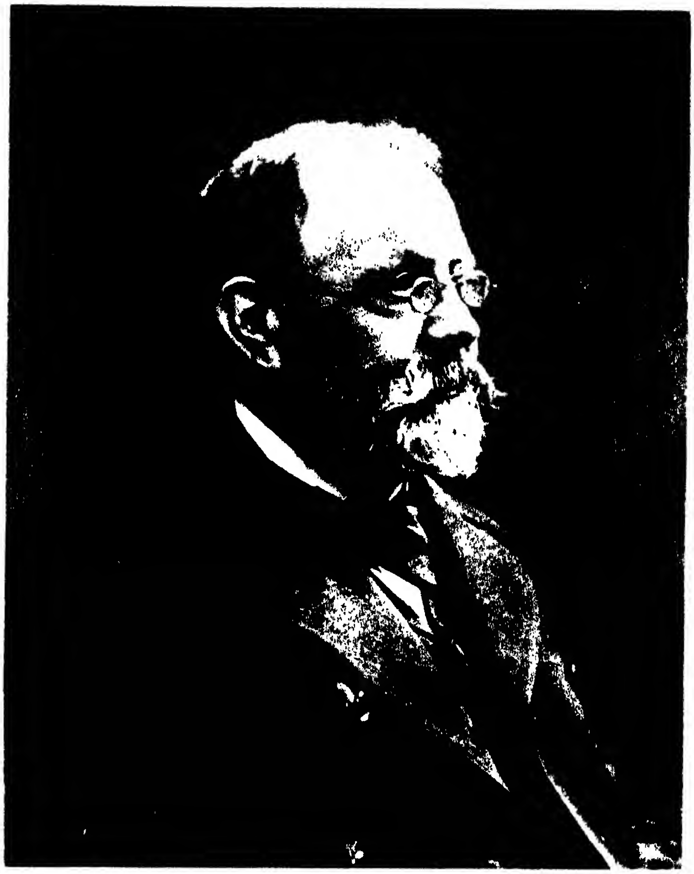
Professor at Karlsruhe, Vienna and Darmstadt. As assistant to Baeyer during his studies on indigo, Friedländer early became interested in the constitution of dyes. Studied isatin and its derivatives; synthesized thionaphthene and determined the composition of the historically famous "Tyrian purple," a dye obtained from the mollusk "murex," and found it to be a dibromindigo. Patented two hundred and thirty-five compounds and processes of the thio-indigo and indigoid dyes. Began (1888) the famous serial collection of patents dealing with dyes, popularly known as "Friedländer." He was an important factor in the expansion of this industry.

JOHANN GOTTLIEB GAHN: 1745–1818.

Professor at the College of Mines, Stockholm (1784). Friend of Bergman and Scheele. Best known for his discovery of metallic manganese (1774) and of phosphorus in bones (1774). As a boy he worked in the mines to help support his widowed mother. "I learned mining," he said, "in the lowest and wettest level." His interests and training led him into mineralogical chemistry and he made much use of the blowpipe and bead tests in qualitative analysis. He was eminent as a practical chemist who presided over large mining and manufacturing interests. It was in the flue dust of one of his sulfuric acid plants that Berzelius discovered selenium.

LUDWIG GATTERMANN: 1860–1920.

Professor at Heidelberg (1889) and Freiburg (1900). Prepared, purified and analyzed nitrogen trichloride although attended with great danger. Studied the reactions of amino-azo-benzene and the dyes of the nitro-anthraquinone series. Developed three reactions for the synthesis of the aromatic aldehydes. Determined the molecular formula for dihydrogen phosphide (P_2H_4). His textbook "Die Praxis des organischen Chemikers" has served to introduce countless youths into the methods of organic laboratory practice since it first appeared in 1894.



ARMAND GAUTIER: 1837–1920.

Professor at Montpellier and Paris (1884). His work lay in the field of sanitary biochemistry. Studied the fixation of nitrogen (1888), discovered carbylamines (1866), and his work on organic arsenical compounds led to modern arsenotherapy. Established the existence of a class of compounds now known as ptomaines (1872).

JOSEPH LOUIS GAY-LUSSAC: 1778–1850.

Professor at the École Polytechnique in Paris. Studied under Berthollet and co-operated with Thénard in a long series of researches. Subsequent to Davy's isolation of potassium, Gay-Lussac and Thénard obtained it by reducing potash with metallic iron. Isolated boron by reducing boric acid with metallic potassium (1808). From his studies of gases he announced that all gases expand equally for equal increments of temperature and that gases combine chemically in simple ratios by volume. With Thénard made the first thorough studies of iodine and cyanogen. Instituted volumetric analysis, especially determination of silver. The "Gay-Lussac tower" of the sulfuric acid plant shows his interest in chemical technology.

GAY-LUSSAC AND BIOT MAKING A BALLOON ASCENSION FOR SCIENTIFIC PURPOSES IN 1804.

GEBER or JABIR IBN HAYYAN (*ca.* 720–813).

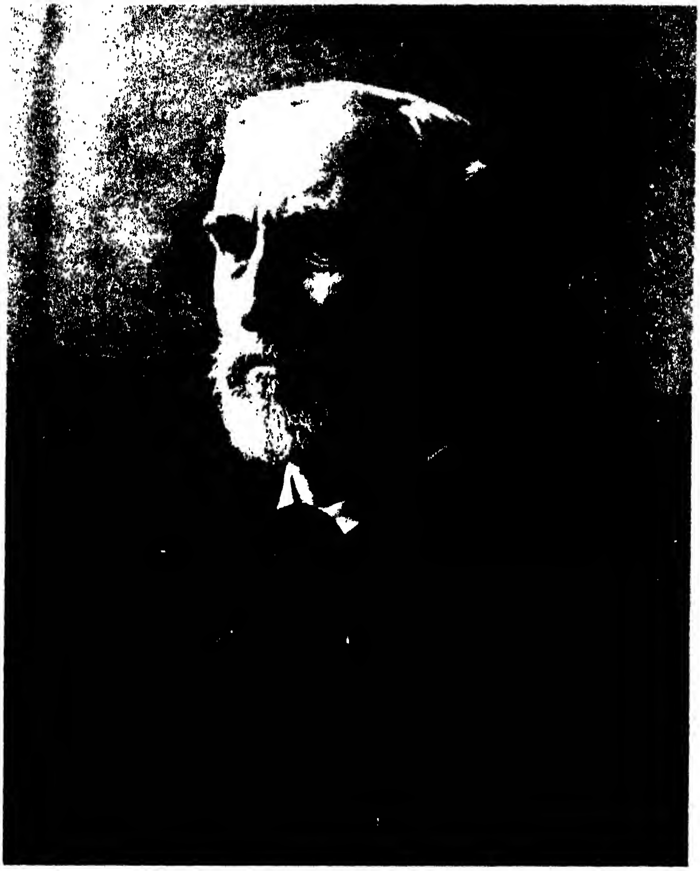
Arab physician; supposed to have lived towards the end of the eighth century. His name and writings exercised a great influence on chemistry throughout the Middle Ages. These writings showed a knowledge of the common metals, salts, acids, and alkalies, their preparation and methods of purification by crystallization, distillation and sublimation. He believed that the metals were compounds of a positive principle which he called sulfur and a negative principle which he called mercury.

ÉTIENNE FRANÇOIS GEOFFROY: 1672–1731.

Professor at the Collège de France (1712–1731). He is best known for his studies on the affinities between acids and bases or metals (1718). This work exercised considerable influence at the time, though with increasing knowledge his tables needed constant revision and were finally discredited by Berthollet. He contributed to the knowledge of chemistry in medicine and was especially severe in his attacks on those who practised alchemical frauds. He is known as "the elder" to distinguish him from his brother, Claude Joseph (1686–1752) "the younger."

CHARLES FREDERIC GERHARDT: 1816–1856.

A French chemical theorist who was a student of Liebig and later held professorships in Montpellier and Strassburg. Most of his work was done in association with Laurent. Gerhardt's work, and especially his writings, finally brought about important changes in the theories of organic chemistry, and paved the way for the valence theory. This he accomplished by his demonstration of homologous series and his theory of types. Discovered quinoline (1842), acid chlorides and anhydrides of monobasic organic acids. Unfortunately his theories did not receive the attention they deserved during his lifetime.



JOSIAH WILLARD GIBBS: 1839-1903.

Graduate of Yale University (1858); studied with Kirchhoff and Helmholtz. Professor of Mathematical Physics at Yale (1871–1903). His papers published in the *Transactions of the Connecticut Academy of Sciences*, and culminating (1878) in the one on "The Equilibrium of Heterogeneous Substances," provide the complete theoretical structure of modern physical chemistry. The work includes the action of gravitational force, electrical forces, and the forces existing between the boundaries of two phases. The "Transactions" in which Gibbs's papers were first published were relatively inaccessible and it was not until Ostwald translated Gibbs's articles and republished them in the new *Zeitschrift für physikalische Chemie* (1892) that they became generally known to the chemical world. Ostwald said they have "given to general chemistry form and content for a hundred years." The transformation a system will undergo when the physical states are altered is known as the "phase rule."

WOLCOTT GIBBS: 1822-1908.

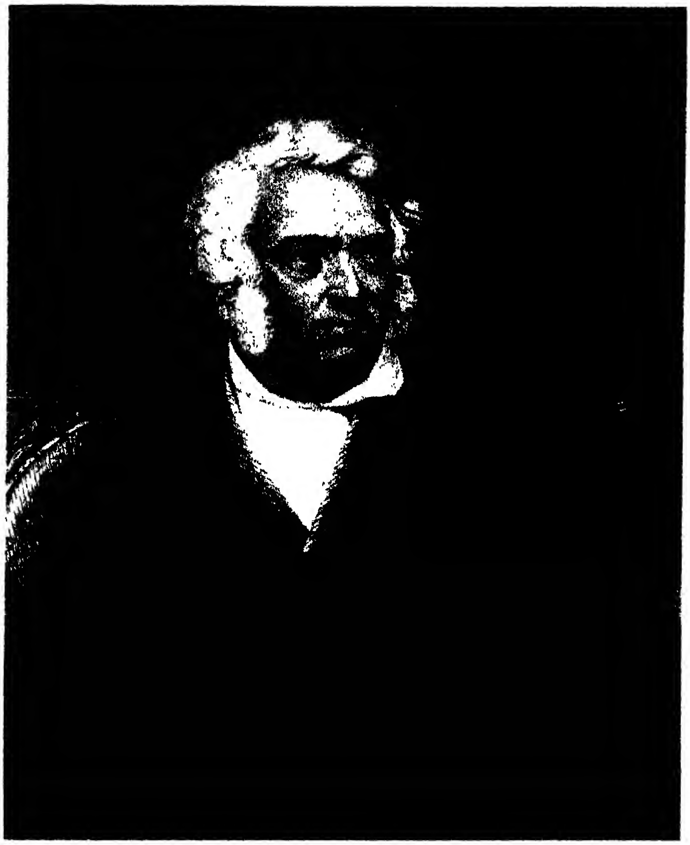
Professor at Harvard University. His studies included compounds of iridium and osmium, the cobalt ammonia complex salts, phosphotungstates and phosphomolybdates. He was instrumental in the development of new analytical methods.

AIMÉ GIRARD: 1830–1898.

Professor of Industrial Chemistry at the Conservatoire des Arts et Métiers (1871) and the Institut Agronomique (1876). Studied the refining of sugar, the manufacture of sulfuric acid and the hydrocelluloses; improved the processes in wine and bread making and distillation and the preparation of vegetable fibers.

JOHANN RUDOLPH GLAUBER: 1604–1670.

Called the first industrial chemist. Born in Germany, resided in Amsterdam (1646–1649) (1655–1670) where he published his "Furni Novi Philosophici" (1648–1650), "one of the most remarkable books on chemistry of the XVII century." Prepared hydrochloric acid from rock salt and oil of vitriol; fuming nitric acid from saltpeter and white arsenic; discovered ammonium nitrate and first prepared arsenic chloride. Prepared the chlorides, nitrates, sulfates and acetates of various metals, studied their properties and suggested uses. First definitely stated the order of activity of the metals. Made acetic acid by wood distillation and separated acetone and benzene (1648) from their raw distillates. Contributed to agriculture, medicine, paints, explosives, glass, and porcelain. Complained that Germany sent her crude products to foreign countries for refining. "Ist unser Holtz, Sand, und Aschen in Deutschland nicht so gut, Crystallinisch Glas daraus zu machen als jenes zu Venedig oder Frankreich?" he asked. Glauber's salt, *sal mirabile Glauberi*, $Na_2SO_4 \cdot 10H_2O$ or sodium sulfate, has important industrial uses today.

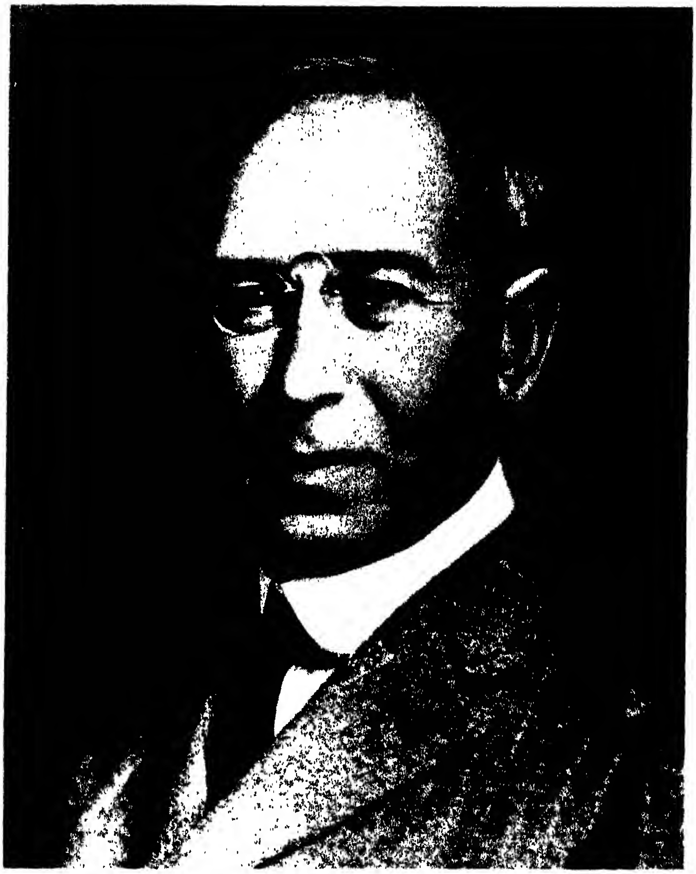


LEOPOLD GMELIN: 1788–1853.

Pupil of Berzelius and Professor of Chemistry at Heidelberg from 1817 to 1851. His theories on radicals and equivalents exercised a large influence at a time when confusion existed. He used H = 1 as the standard for atomic weights. Discovered taurine in ox-bile (1824), and potassium ferricyanide (1827). Was first to recognize that organic chemistry is the chemistry of the compounds of carbon. Gmelin is best known by his famous "Handbook of Chemistry" (1817) which passed through many editions and was widely translated. Its successor is the widely known Gmelin-Kraut "Handbuch der anorganischen Chemie."

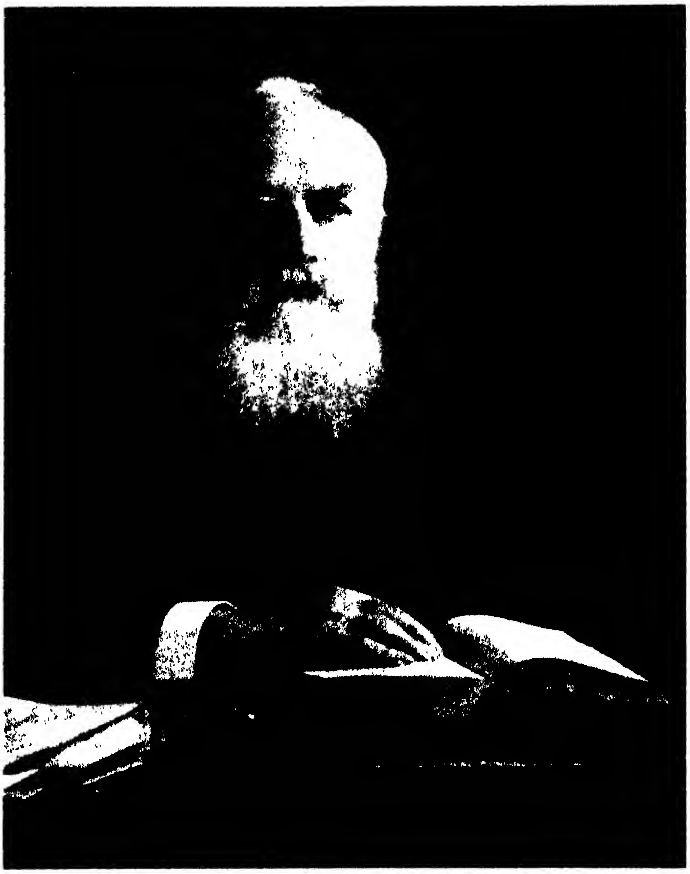
HANS GOLDSCHMIDT: 1861–1923.

As a former student of Bunsen the reduction of metallic oxides with aluminum by Vautin in 1892 appealed to Goldschmidt and he devoted himself to the development of the industrial possibilities of the reaction. His efforts were successful and he gave (1905) to industry carbon-free chromium, manganese and cobalt by the alumino thermic process and the welding process known by his name. His brother Karl (1857–1926) invented the important chlorine process for recovering tin from tin plated iron.



MOSES GOMBERG: 1866–1947.

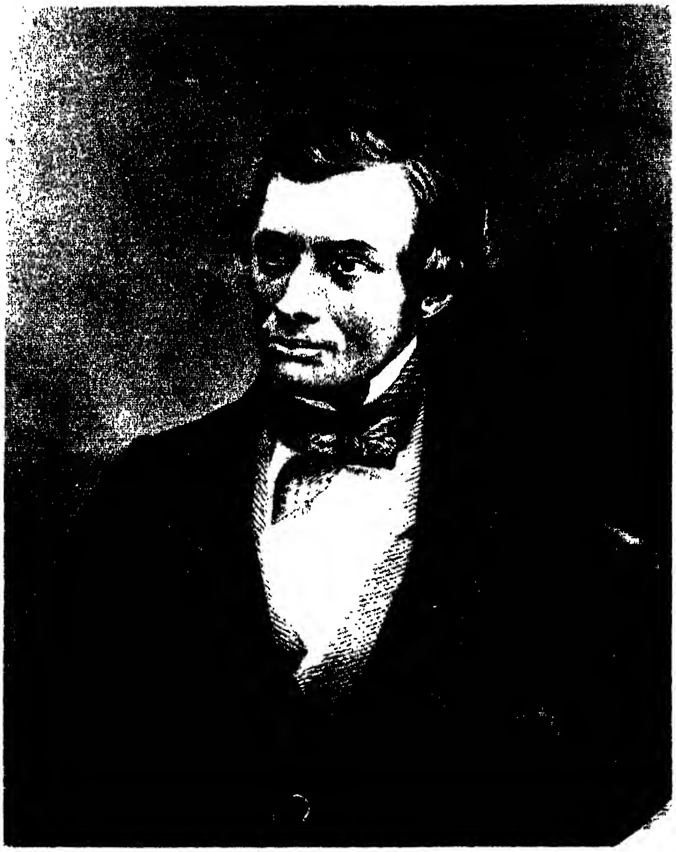
A Russian by birth, he escaped to this country with his father in 1885. Graduate of the University of Michigan (1890). Studied under Baeyer and Victor Meyer. Professor of Chemistry at the University of Michigan (1904). During his studies at Heidelberg he attempted to prepare hexaphenylethane by the action of zinc on triphenylchlormethane. He obtained what he named triphenylmethyl $(C_6H_5)_3C-$, showing carbon in the trivalent condition (1910). The result was so unusual that much doubt was expressed at the time as to the correct interpretation of the results. However, Gomberg's discovery of trivalent carbon is now accepted.



CARL GRAEBE: 1841–1927.

Born in Frankfurt; pupil of Bunsen and Kolbe; Professor at Geneva 1878–1906. Studied the quinones and phthalic acid; synthesized carbazole, phenanthrane, and alizarin and confirmed the two-ring nature of naphthalene. Graebe's fame is associated with Liebermann in the discovery that anthracene is formed by the reduction of alizarin. With Liebermann he succeeded in synthesizing alizarin by oxidizing anthracene to anthraquinone and fusing with alkalies. On January 11, 1869, he prepared the dye before the members of the Berlin Chemical Society — an epochal date in the history of the coal-tar dye industry. He continued his writings into his seventy-ninth year. Received the Perkin, Lavoisier and Berthollet medals.

Carl Graebe at the time of his work with Liebermann (1867–1868) which led to their synthesis of alizarin and the production of the dye, Turkey Red.



THOMAS GRAHAM: 1805–1869.

Professor at Glasgow and University College, London. Worked on the acids of phosphorus and arsenic and showed that they were polybasic. He discovered the law that the rates of diffusion of gases are inversely proportional to the square roots of their densities. He studied dialysis and distinguished "crystalloids" and "colloids," naming the two classes and founding what has become a special branch of chemistry.

JOHANN PETER GRIESS: 1829–1888.

German by birth; pupil of Kolbe; assistant to Hofmann in London (1858); director of the brewery firm of Allsopp & Sons, England (1862). Although most of his life was spent in directing the activities of the brewery he continued his researches in pure chemistry and studied the azo and diazo compounds in all their reactions. The decomposition of diazonium salts with the liberation of nitrogen and the formation of phenols was recognized and led to his discovery of α-naphthol (1862). His discovery of the action of nitrous acid on amines has become one of the vital steps in making certain dyes. Hofmann said "the name of Peter Griess rings ever clearer and clearer in the widely expanding coal-tar industry."

VICTOR GRIGNARD: 1871–1935.

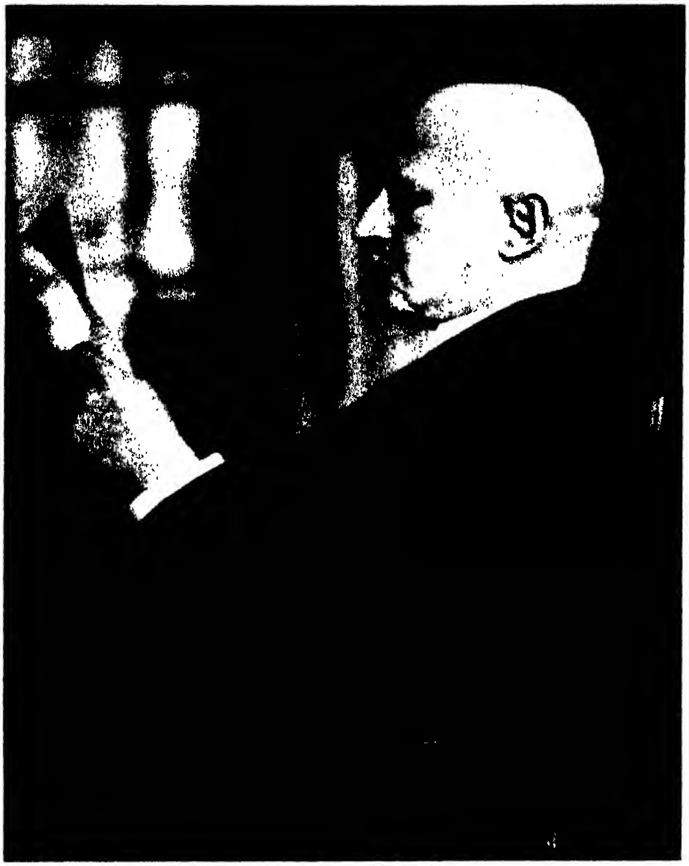
Professor at Lyon (1906) and Nancy (1909). Discovered the action of magnesium on the alkyl halides (1900), known as the "Grignard reaction," which gave great impetus to the synthesis of many kinds of carbon compounds (Grignard's syntheses). Shared the Nobel Prize in 1912 with Sabatier.

LOUIS ÉDOUARD GRIMAUX: 1835–1900.

Professor at the École Polytechnique as successor of Cahours. Worked on nitriles, the aromatic glycols (1870), the acid ureides (1871), allantoin (1876), and the synthesis of citric acid (1881). Transformed morphine into codeine and showed codeine to be a methyl ether of morphine. Prepared quinine and other alkaloids and the salts of quinine (1892). Due to his support of Zola in maintaining the innocence of Dreyfus he was deprived of his professorship. His "Life of Lavoisier" (1888) was the first extensive biography on this founder of modern chemistry. Grimaux aso was the biographer of Gerhardt (1900).

PHILLIPPE-AUGUSTE GUYE: 1862–1922.

Professor at Geneva. Pupil of Graebe and Friedel. Studied the quantitative relation between optical rotatory power and the mass of the substituting group. Redetermined the atomic weights of nitrogen, silver and chlorine with a degree of exactness surpassing all previous work. Studied gas densities, compressibilities and critical data. Determined the value for "R" in the gas equation PV = RT (1900). Founded the *Journal de Chimie physique* in 1903, which he edited until his death. Received the Davy Medal (1921).



FRITZ HABER: 1868–1934.

Professor at Karlsruhe (1906) and Director of the Kaiser Wilhelm Institut, Berlin (1911). Studied the thermodynamics of the gas reactions and equilibria between nitrogen, hydrogen and ammonia with varying temperatures and pressures. Applied his results to the catalytic production of ammonia and developed the process known by his name (1906). This process supplied Germany with its needed nitrates during the recent great wars and is today a prime source of the fixed nitrogen needed for the world's fertilizers. Received the Nobel Prize in 1919, and the Rumford Medal in 1932. Died in exile.

CHARLES MARTIN HALL: 1863–1914.

Inventor of the electrolytic process for the production of aluminum and founder of the aluminum industry in America. As a student at Oberlin he learned of the possibilities of aluminum and was heard to say, "I'm going after that metal." He began his efforts with home-made apparatus at once and continued with them throughout his college course. Six months after his graduation he visited his former professor and holding out a dozen silvery globules in the hollow of his hand said, "Professor, I've got it." Hall was then twenty-one years of age. He received the Perkin Medal in 1911.

ALBIN HALLER: 1849–1925.

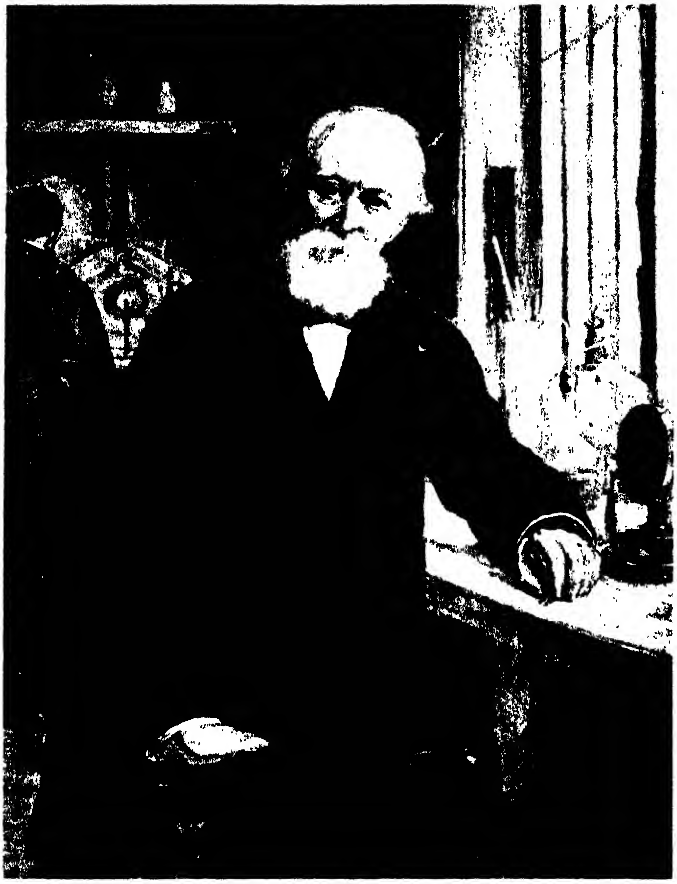
Professor at Nancy and at the Sorbonne, Paris. Studied the influence of unsaturation and ring formation on optical activity and the synthesis of cyano-fatty acids. His studies on camphor extending over a period of nearly a score of years resulted in the synthesis of borneol (1891), a knowledge of the constitution of camphoric acid (1893), and the synthesis of camphor (1895).

MAURICE HANRIOT: 1854–1933.

Professor at the Academy of Medicine, Paris. Pupil of Wurtz. Studied the derivatives of glycerine and the substitution of hydrogen by the alkali metals in the hydrocarbons. Discovered chloralose and its isomer parachloralose (1894) by the union of chloral anhydride and glucose. With Richet studied the respiratory exchange of man and animals. Discovered the ferment lipase in the blood (1896). Prepared collargol.

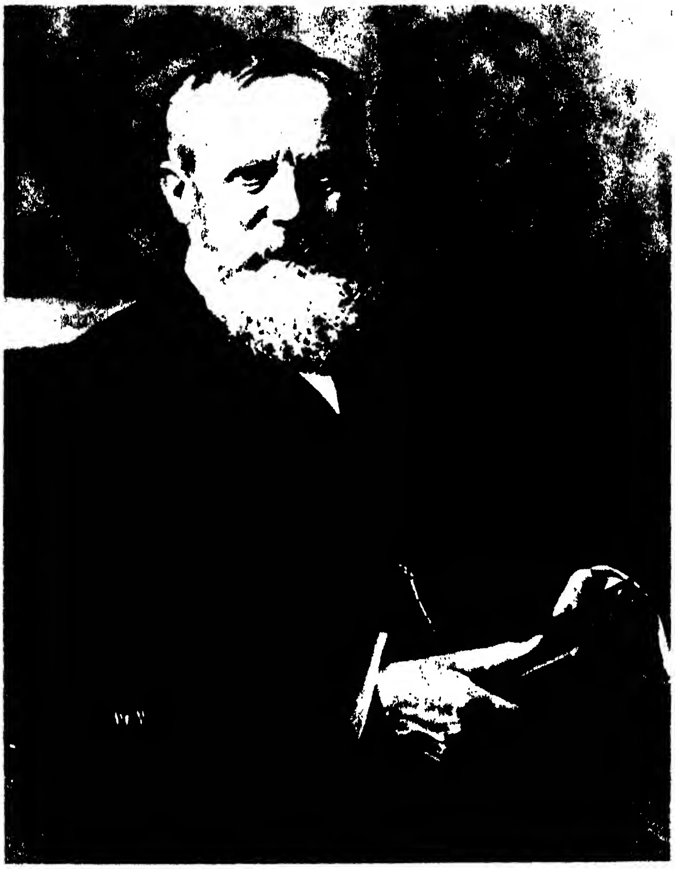
ARTHUR HARDEN: 1865–1940.

Professor of Biochemistry at the University of London (1912). His researches lay in the field of fermentation. He showed that the cell-free juice expressed from yeast could be separated by ultra-filtration into co-zymase and apo-zymase (1905), thus demonstrating the complex nature of zymase and that enzymes consist of a ferment and a co-ferment. Discovered that the presence of inorganic phosphates causes an increase in the speed of fermentation and developed the theory that in fermentation one molecule of sugar ferments and another reacts with the phosphoric acid. Received the Davy Medal in 1935 and shared the Nobel Prize with von Euler-Chelpin in 1929.



PAUL HAUTEFEUILLE: 1836–1902.

Professor at the École Normale Supérieure. His name is associated with Sainte-Claire Deville, Debray and Troost in his many researches in the field of Mineralogical Chemistry. He determined the composition and synthesized many minerals and determined the temperature at which they dissociate and the temperature at which a mineral will crystallize in one crystal system or another. He also worked on the oxides of nitrogen.



WALTER HEMPEL: 1851–1916.

Professor at Dresden. Pupil of Bunsen, from whom he derived his interests in gas analysis. Extended the laboratory methods of Bunsen and devised the pipette and burette known to all chemistry students by his name. Studied the reactions occurring in the lead-chamber process, the recovery of phosphorus, and the electrolytic production of sodium carbonate. Determined the atomic weight of cobalt and developed a method for the combustion of organic compounds under high pressure.

AUGUST WILHELM HOFMANN: 1818–1892.

A pupil of Liebig; professor at the Royal College of Chemistry, London (1845–1864) and later at the University of Berlin (1865). Because of his work on aniline (1843) and benzene (1865) in coal-tar and his preparation of numerous dyes, the birth of the coal-tar dye industry is commonly regarded as occurring in his London laboratory. His work was largely with aniline which later proved so important in the dye industry. Perkin, the discoverer of "mauve," and Griess, the discoverer of the azo reactions, were assistants in his London laboratory. Hofmann was famous as a teacher both in England and Germany and his influence extended far beyond the walls of his laboratory. His memorial lectures collected in "Erinnerungen an vorangegangen Freunde" (three volumes) are famous. The headquarters of the German Chemical Society in Berlin was called the Hofmann Haus. It was totally destroyed in World War II. Awarded the Copley Medal in 1875.

AUGUST WILHELM HOFMANN: 1818–1892.

Probably at the time of his life in London.

GRAEBE HOFMANN LIEBERMANN

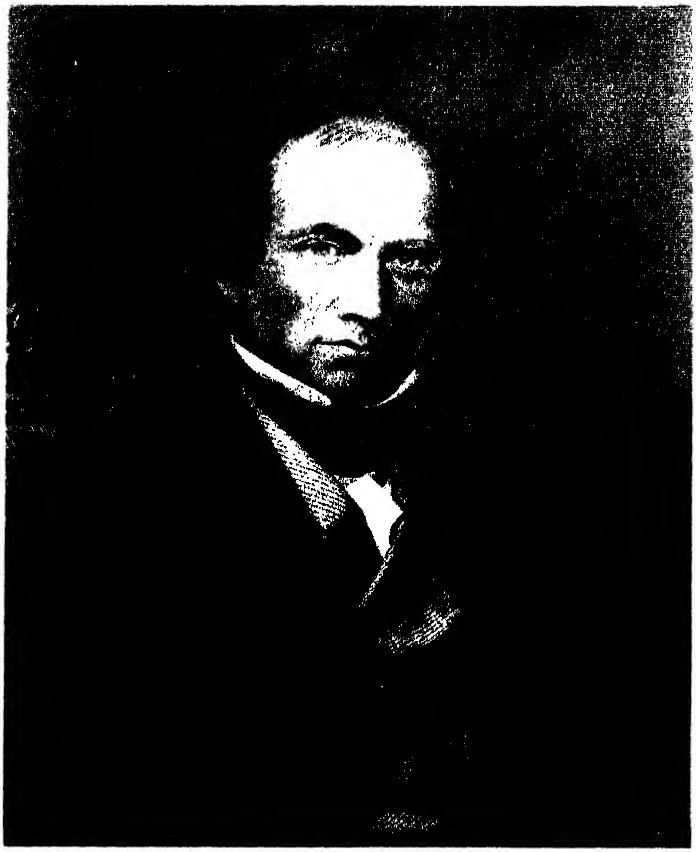
FOUNDERS OF THE COAL-TAR DYE INDUSTRY.

THE SYNTHESIS OF ALIZARIN

From a painting in the possession of the Chemistry Department of the Massachusetts Institute of Technology. The title of this picture and the subjects named are more or less conjectural. It is an oil painting by Anna M. Lea, dated 1869. It was on January 11, 1869 that Graebe and Liebermann at a meeting of the Berlin Chemical Society, with Hofmann as the presiding officer, announced their discovery of the synthesis of alizarin and prepared the dye before the audience. This is an epochal date and made a sensation throughout the chemical world. Efforts to learn the history of the painting and how it came into the possession of M. I. T. have been fruitless to date. Anna Lea was painting in Dresden and Paris in 1869. "Her father through his business interests had something to do with coal-tar dyes," writes a member of the family. President Crafts of M. I. T. resided in Paris for twenty years (1874–1891) carrying on his chemical researches and may have secured the painting.

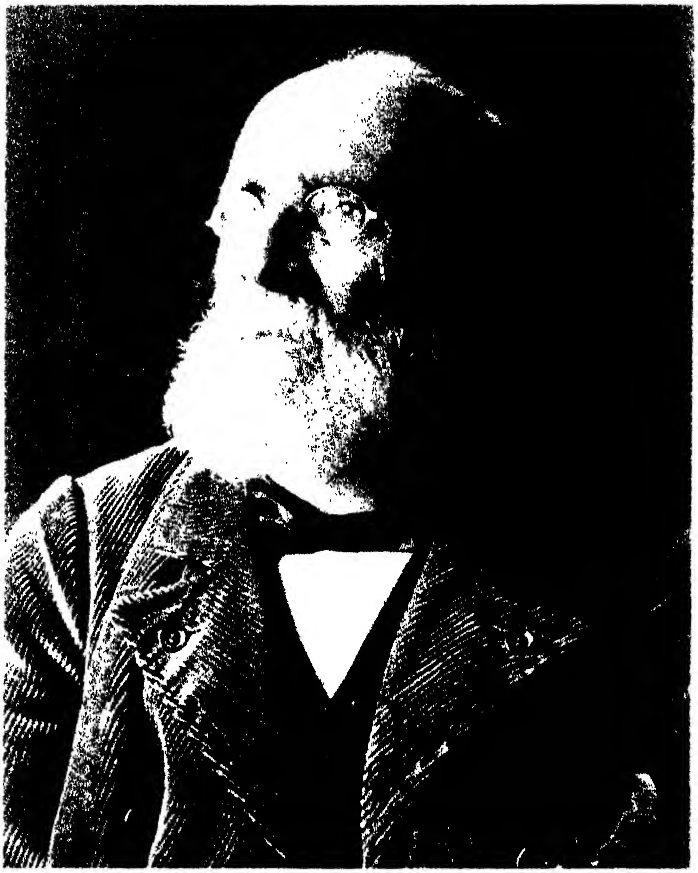
FELIX HOPPE-SEYLER: 1825–1895.

Professor at Strassburg (1872). Leading physiological chemist of his time. There was no branch of this field which he did not investigate and illuminate. His main interest, however, was in the composition of the blood. He discovered haemoglobin (1862) and showed its function as an oxygen carrier, and its affinity for carbon monoxide. Discovered the absorption spectra of the blood; developed methods for detecting human blood; separated the coloring materials of the blood; explained the cause of caisson disease ("bends"); discovered lecithin and cholesterin and showed their presence in the protoplasm of plants and animals. Recognized and gave the name of "proteids" to a class of nitrogen compounds. Founded (1877) the important "Zeitschrift für physiologische Chemie," popularly known as "Hoppe-Seyler."



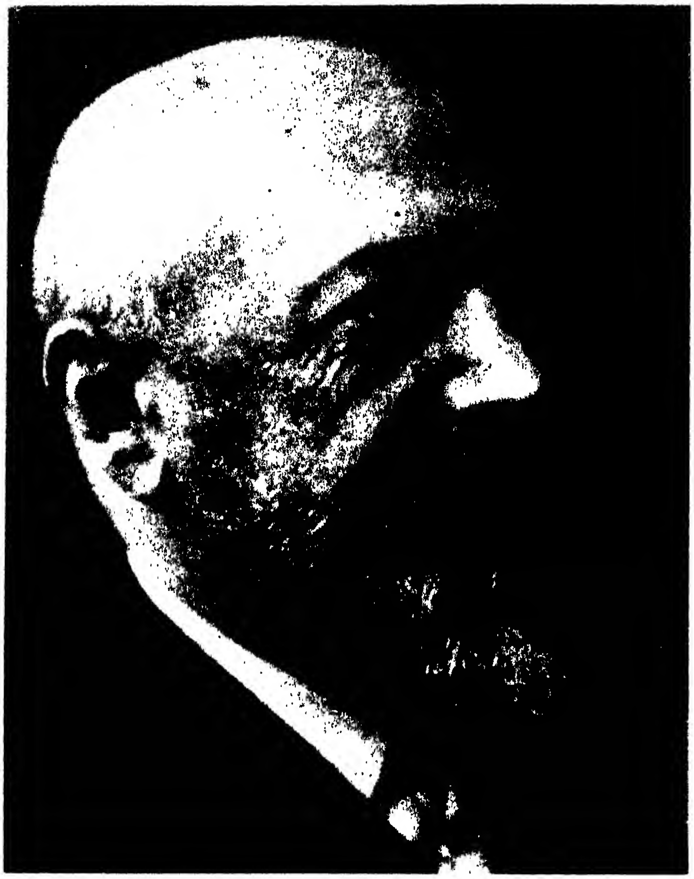
EBEN MORTON HORSFORD: 1818–1893.

Pupil of Liebig at Giessen and Professor at Harvard. Active in organizing the Lawrence Scientific School where he established one of the first laboratories for chemical instruction in America. His investigations were largely in the chemistry of foods.



AUGUST FRIEDRICH HORSTMANN: 1842–1929.

Pupil of Bunsen, Kopp and Kirchhoff and Professor at Heidelberg. As the first to work in the field of the thermodynamics of chemical reactions he may be regarded as a founder of Physical Chemistry. Applied the kinetic theory to chemical equilibrium and the dissociation of gases (1868); stated the simple gas equation $PV = RT$. Studied heats of formation, nature of solution, the vapor densities of ammonium sulfide, hydrogen sulfide and ammonium chloride, and their deviations from the law of Gay-Lussac. Several of his contributions were so original and fundamental that they have been included in Ostwald's "Classics." From childhood his eyesight was poor and during his active years he was unable to make his own experimental observations. Finally complete loss of sight forced his relinquishment from active work but he continued his interests in the progress of chemistry and lived to see his theories and work recognized by the scientific world.



PAUL JACOBSON: 1859–1923.

Professor at Heidelberg (1891) and later Secretary of the German Chemical Society and Editor of the "Berichte" (1896). He revised and edited editions of "Beilstein." He had a special taste and aptitude for chemical literature that made his services as an editor invaluable. His researches were with the phenyl mercaptans, the reduction of azo compounds, and the rearrangement of the hydrazo compounds. He was associated with Victor Meyer in writing the famous "Lehrbuch der organischen Chemie" which he carried to completion after Meyer's death.

CHARLES JAMES: 1880–1928.

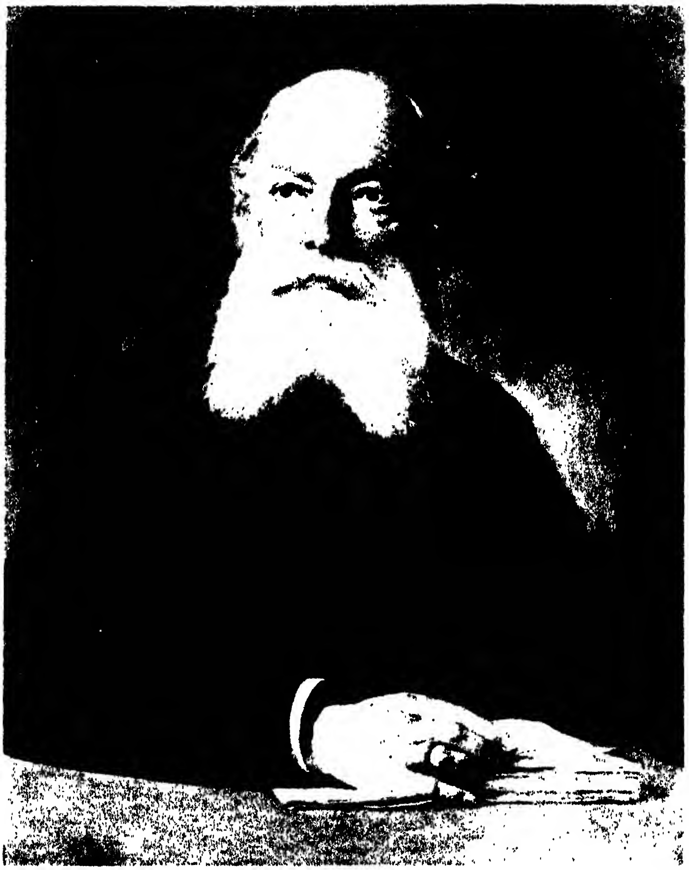
Of English birth. Studied with Ramsay before coming to the United States in 1906. Professor at the University of New Hampshire (1912). His interests and work lay in the field of the rare earths. These he prepared and purified in large quantities. He developed a method of the separation of the cerium group through a study of the bromates. He also developed a method of separation by hydrolysis of the nitrites which was used in determining the atomic weights of yttrium, holmium and other members of this group. Another method of separation, known by his name, was by a fractional crystallization of the double magnesium nitrates. He prepared many salts of uncommon composition as the sebacates, cacodylates, pyromucates and tungstates, to mention a few. He separated large quantities of the compounds of lutecium but withheld announcement of the discovery of lutecium until final confirmation could be obtained. While awaiting this confirmation Urbain made his report and was credited with priority. In like manner James effected a separation of the element No. 61, but Hopkins published his results while James's preparation was being subjected to an x-ray check. Thus James was twice denied priority due to his insistence on full confirmation before making public his work.

ÉMILE CLÉMENT JUNGFLEISCH: 1839–1916.

Professor at the École de Pharmacie (1876) and the Sorbonne (1908). Pupil of Berthelot. Studied the physical properties of the chlorine derivatives of benzene and showed the relation between the number of substituting groups and the melting points. Showed that the different forms of tartaric acid were transformed into each other when heated in water and that an equilibrium existed. Converted ethylene into succinic acid and showed that camphoric acids exist in four isomeric forms; resolved inactive malic and lactic acids into their active forms. Worked with Berthelot on the law of partition (1872) and with Lecoq de Boisbaudran on the isolation of gallium and indium in quantity.

GEORG WILHELM AUGUST KAHLBAUM: 1853–1905.

Professor at Basel. Worked in the field of physical chemistry. Developed boiling-point methods and conditions necessary for securing accurate results. Devised a mercury vacuum pump and carried out the distillation of metals in vacuum. He had a great interest in the history of chemistry and wrote many monographs on the early development of the science.



FRIEDRICH AUGUST KEKULÉ: 1829–1896.

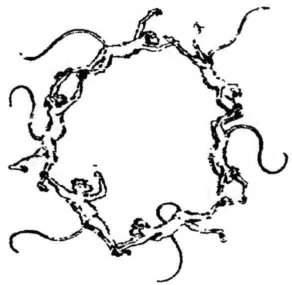
Studied under Dumas, Wurtz, Gerhardt and Liebig. Professor at Ghent (1858) and Bonn (1867). Kekulé arrived on the chemical scene at a time when the question of types, radicals and valence was perplexing the minds of investigators. He proposed the tetravalence of carbon in 1858, simultaneously with Couper, and the chain formation of the aliphatic series. This he extended to the ring formation for benzene and the aromatic series in 1865. Before he published his theory he spent several years in testing its validity which has now become one of the best substantiated of scientific generalizations. "The most brilliant piecc of scientific prediction to be found in the whole range of organic chemistry." "The debt which both chemical science and chemical industry owe to Kekulé's benzene theory is incalculable," wrote Japp. Kekulé's "Lehrbuch der organischen Chemie," published in 1861, marks an epoch in the history of the science. Received the Copley Medal in 1865.

KEKULÉ: (A page from the "Berichte der durstigen chemischen Gesellschaft Unerhörter Jahrgang No. 20. Ausgegeben am 20.9.1886.")

At a celebration of the twenty-fifth anniversary of the benzene theory Kekulé gave an account of its origin. During his sojourn in London he was accustomed to ride across the city on the bus-top and on one occasion fell asleep. In a dream, atoms of carbon whirled before his eyes and finally lengthened into a chain. On awakening he put the dream to test with pencil and paper and so the structural theory of the tetravalent carbon was born. Later, during his residence in Ghent, while trying to work at his desk one evening he fell asleep and again in a dream he saw chains of carbon atoms like snakes wiggling before his eyes, when one seized another's tail and formed a ring. Kekulé awakened and spent the rest of the night putting to test the possibilities of a ring structure for benzene. "Let us learn to dream," said Kekulé, "but let us beware of publishing our dreams before they have been put to the proof of the waking understanding." These dreams of Kekulé were burlesqued in a leaflet put out at a celebration of the German Chemical Society. This witty leaflet purported to be the "Berichte der durstigen chemischen Gesellschaft," and in type, paper and make-up was an exact copy of the "Berichte der deutschen chemischen Gesellschaft." It contained an article "Zur Constitution des Benzols," showing complete analogy between the carbon atom and the monkey with the possibilities of tautomerism as shown in the above.

reichen, so erhält man ein höchst vollkommenes Analogon des Kekulé'schen Benzolsechsecks:

Fig. 1.



Nun aber besitzt der genannte Macacus cynocephalus ausser seinen eigentlichen vier Händen noch ein fünftes Greifwerkzeug in Form eines caudalen Appendix. Zieht man diesen mit in Betracht, dann gelingt es, die 6 Individuen des gezeichneten Ringes auch noch in anderer Weise mit einander zu verbinden. So entsteht das nachfolgende Bild:

Fig. 2.

Es erscheint mir nun höchst wahrscheinlich, dass die Analogie zwischen Macacus cynocephalus und dem Kohlenstoffatom eine voll-

EDWARD KELLEY: 1555–1595.

A rogue and impostor; clairvoyant for John Dee, the scholar whom he duped. He claimed to have found in the ruins of Glastonbury Abbey an alchemical manuscript of St. Dunstan and two powders by which he could produce gold. In Prague in the presence of Dr. Von Hayek, director of Rudolph II's alchemists, Dee and Kelley produced gold from mercury. Kelley rose in Rudolph's favor by giving him a taste of the Elixir of Life and by allowing him to make a transmutation unaided. This Kelley accomplished by secreting his brother in a chest with a false bottom, who introduced the gold into the crucible when all had left the room. As a reward Kelley was made Court Alchemist, given landed estates and created a Knight of Bohemia (1590), with the title *Sir Edward, the Golden Knight*. After three years of luxury and swindling he fell into disfavor, was imprisoned and put to torture. He died trying to escape from his dungeon. Rudolph confiscated all his estates.

GUSTAV KIRCHHOFF: 1824-1887.

Professor of Physics at Heidelberg (1854-1874) and Berlin. With Bunsen he developed the spectroscope which opened new fields for analysis and led to the discovery of rubidium and cesium and "many elements that still unsuspected lay hidden in the regions of the Unknown." The Fraunhofer lines in the sun's spectrum were a mystery until Kirchhoff showed that glowing vapors absorb the same radiations that they emit. Victor Meyer used to relate in his lectures how Bunsen and Kirchhoff were discussing this mystery on one of their usual walks up the Neckar valley when Kirchhoff made the above suggestion and Bunsen replied, "Gustav, du bist verrückt." Kirchhoff on their return immediately constructed a crude apparatus which showed his theory was correct. Excitedly he rushed to Bunsen exclaiming "Ich bin verrückt, Ich bin verrückt." Kirchhoff's discovery showed that the same elements that exist on the earth are present in the sun and stars.

JOHAN KJELDAHL: 1849–1900.

Director of the Carlsberg Laboratories, Copenhagen. Studied enzymes, especially invertin, and methods for the determination of different sugars in the presence of each other. Revised the tables of the reducing powers of different sugars. Devised (1883) the well-known "Kjeldahl method" of determining protein by converting the nitrogen to ammonia. This method is in widespread use, especially in agricultural and bio-chemistry.

MARTIN HEINRICH KLAPROTH: 1743-1817.

Apothecary. First professor of chemistry at the University of Berlin (1810) and the leading chemist in Germany of his time. Discovered uranium (1789), zirconium (1789), cerium (1803), and titanium (1795). Staunch supporter of Proust and leader of the antiphlogistists in Germany. Distinguished for care and exactness in his work. Hofmann said of him, "Klaproth will remain to us for all time the model of the true investigator of science."

FRIEDRICH KNAPP: 1814–1904.

Professor at Giessen (1847) and Brunswick (1863). He worked on industrial problems of tanning, glass and cement. In his work on tanning he studied the action of metallic salts and the modern quick-process tanning with chromium salts is the outcome of his investigations. He also studied the conditions necessary for the successful production of ultramarine. Author of "Lehrbuch der chemischen Technologie" (two volumes). A leader in the study of chemical-technical problems.

HERMANN KOLBE: 1818–1884.

Professor at Marburg and Leipzig (1865.) For forty years Kolbe held a commanding position in German chemical thought and his influence as a teacher ranks him with Liebig, Wöhler, Bunsen and Hofmann. His work centered on the constitution of organic radicals which later under Frankland led to the theory of valency. Synthesized acetic acid (1842), trichloromethyl-sulphonic acid (1845); converted alkyl cyanides to fatty acids (1848); electrolyzed fatty acids (1849); synthesized salicylic acid (1860) and showed its value as a preservative; determined the composition of lactic acid, alanin and glycocoll; synthesized taurin (1862), and malonic acid (1864). Discovered nitromethane (1872) and predicted the existence of secondary and tertiary alcohols. Edited the "Handwörterbuch der Chemie," and was long editor of the "Journal für praktische Chemie." His years of rigid and critical training prevented him from accepting the newer ideas of stereochemistry as proposed by Van't Hoff and Wislicenus and which he compared to the belief in witchcraft, and he combated them vigorously until his death. Wislicenus became his successor at Leipzig.

HERMANN KOPP: 1817–1892.

Pupil of Gmelin and Liebig. Professor at Giessen and Heidelberg (1863). Best known for his "History of Chemistry" (four volumes). Hofmann said of it "after fifty years there is no historical work on chemistry that can even remotely compare with it." In his researches he endeavored to deduce a relationship between the physical properties, the molecular weights and the chemical composition of compounds. With Liebig, he founded (1849) the "Jahresbericht der Chemie."

JOHANN KUNCKEL: 1630–1703.

Pharmacist and Court Alchemist for several Electors of Germany and Charles XI of Sweden, who created him Baron of Löwenstein. In charge of the Royal Laboratories of Dresden. Improved the processes of making glass and prepared ruby-glass with purple-of-Cassius; developed the process of tinning and silvering of copper and discovered mercury fulminate. His treatise on glassmaking, *Ars Vitraria* (1679), was a recognized authority for many years. He discovered the secret process by which Brand had prepared phosphorus (1669) and demonstrated its properties at many of the Courts of Europe; he was first to cast it in sticks and first to describe red phosphorus. Although he believed in alchemy he was no charlatan and denounced all duplicity. As a firm believer in experimentation his studies contributed greatly to the knowledge of the time and he may be regarded as the most advanced chemist of his century.

ALBERT LADENBURG: 1842–1911.

Pupil of Bunsen and Kekulé. Professor at Kiel (1873) and Breslau (1889). Showed the equivalence of the hydrogen atoms in benzene and the structure of the ortho, meta and para compounds in benzene for which he proposed his prismatic structure. Synthesized piperidine, pyridine, and coniine; proved the formula for tropine, the composition of ozone, the asymmetric nature of nitrogen in some organic compounds. In his sixty-third year he lost a leg, his wife died and his eldest son was drowned, but in spite of these afflictions he continued his work, visiting the students in his laboratory in a wheel chair. His "Handbook of Chemistry" (thirteen volumes) and "History of Chemistry" were authoritative. From 1865 to 1911 he published two hundred and seventy-five articles besides his Handbook. Received the Davy Medal.

HANS HEINRICH LANDOLT: 1831–1910.

Born in Zurich. Studied with Mitscherlich, Rose and Bunsen. Professor at Bonn, Aachen and Berlin. His studies on the optical properties of compounds made him one of the founders of physical chemistry. His work on the constancy of weight during chemical reactions extended over many years and his weighings were to 0.001 of a milligram. He was an example of Bunsen's characterization that "Ein Chemiker, der kein Physiker ist, ist überhaupt gar nichts." His work which extended over a period of sixty years was of the finest type and an example for future generations. In his last days he raced with death to complete the compilations of some of his results while under the greatest pain. Landolt-Börnstein "Tables" have been classic since issued in 1883.

AUGUSTE LAURENT: 1807–1853.

Pupil of Dumas; Professor at Bordeaux (1838); Assayer of the Paris Mint (1848). The name of Laurent is inseparably associated with that of Gerhardt in an attempt at a systematic classification of organic compounds known as the Nucleus Theory (1837) which displaced the dualistic theory of Berzelius. He distinguished between equivalent, atomic and molecular weights (1843) at a time when these terms were hopelessly confused, but his ideas were not appreciated for many years. Discovered anthracene (1832), anthraquinone (1835), phthalic acid (1836), phthalic anhydride and phthalimide. Identified phenol as carbolic acid (1841). Showed the relation of ethers to oxides and of alcohol to water (1846). He proposed a geometrical configuration for the carbon radicals and was thus one of the early chemists to conceive of stereochemistry. Laurent died of consumption in his forties. Gerhardt wrote of his friend's death, "there were few at the funeral with no words spoken at the grave." The picture above is from a portrait made by his daughter and given to the University of Bordeaux by Madame Laurent.

ANTOINE LAURENT LAVOISIER: 1743–1794.

French scientist and founder of modern chemistry. A pupil of Rouelle who taught him to "verify his theories by experiment." At the age of twenty-three he received a gold medal from the Academy for a memoir on the best method for street lighting. Showed by the use of the balance that the age-old dogma of the change of water to earth was false (1768). Examined the action of carbon on metallic oxides and the combustion of phosphorus and sulfur (1772). Reported on the nature of combustion (1775) in which he advanced his new theory of combustion. Showed that one-fifth of the volume of air was removed by phosphorus or mercury, that this volume could be recovered and that the gas was a vigorous supporter of combustion and was respirable (1777). Analyzed water by passing steam over hot iron filings (1783). With Morveau, Berthollet and Fourcroy formulated a new system of chemical nomenclature (1787) which occupied four years in preparation. This system is still in use. Showed the composition of wax and sugar and enunciated the Law of the Conservation of Matter (1784). Studied respiration and the source of animal heat (1790). During the Reign of Terror he was guillotined May 8, 1794, on the charge of "adding water to the people's tobacco." His book *Traité élémentaire de Chimie* published in 1789 marked a new epoch in Chemistry. He served the State and the Academy on numerous commissions. Much of his apparatus may be seen in the Conservatoir des Arts et Métiers. This portrait by Jacques Louis David, painted from life in 1788, was in the possession of Madame Lavoisier's family until it was purchased by John D. Rockefeller, Jr. in 1925. The painting now hangs in the Rockefeller Institute.

LAVOISIER CONVERTS BERTHOLLET TO THE NEW THEORY OF COMBUSTION.
A mural painting by Chartran in the Hall of the Sorbonne.

Lavoisier reported on the "Nature of Combustion" to the French Academy in 1775, but it was not until 1783 that he made a direct attack on the Phlogiston Theory. By 1785 but few chemists had accepted his views, even his friends and associates had held aloof, but in this year Berthollet was convinced of the correctness of Lavoisier's views and became an ardent convert. De Morveau and Fourcroy gave their allegiance to the doctrine in 1786 and 1787, but it was not until 1789 that his theory may be regarded as definitely established. Cavendish and Priestley never accepted the theory and at one time Lavoisier was alleged to have been burned in effigy in Germany as "a heretic of science."

LAVOISIER IN HIS LABORATORY DURING HIS STUDIES ON RESPIRATION.
From a sketch made by Madame Lavoisier.

Among the many subjects which Lavoisier investigated was that of respiration and the production of animal heat. During these studies (with Laplace) he confined a guinea pig in oxygen for ten hours and measured the carbon dioxide produced and concluded that the change from carbon to carbon dioxide was the source of animal heat (1779). Later he measured the volumes of air breathed by a man at rest and at work and showed that his temperature remained constant. He studied the products of respiration and transpiration by having the subject wear a suit of oiled silk so that the gases eliminated might be collected (1790). He concluded "respiration is merely a slow combustion of carbon and hydrogen which is similar in every respect to that which occurs in a lighted lamp or candle, and from this point of view animals that breathe are really combustible bodies which burn and are consumed." * In these studies he showed that animals could live in an atmosphere of one part oxygen and four parts hydrogen and concluded that hydrogen was therefore non-poisonous and that nitrogen takes no part in supporting life.

*Cochrane, "Lavoisier."

THE ARREST OF LAVOISIER.
A painting by the artist Ludwig von Langenmantel in the Landesmuseum at Münster.

For many years Lavoisier had been one of a company commissioned by the government to collect the taxes. To this office Lavoisier brought his keen mind and great ability and introduced many reforms to lessen the harshness of the orders. His integrity and sympathy for the less fortunate were recognized by all. However, during the Reign of Terror the fact that he had formerly been associated with the tax commission brought him under suspicion. He was placed under arrest February 8, 1794. On May 7 he was told to prepare for trial, on May 8 the trial took place and he was found "guilty of having added water to the people's tobacco" and together with forty-seven others he was guillotined in the Place de la Concord within a few hours. During the trial Coffinhal, the presiding judge, is reported to have said: "The Republic has no need of savants." A better appreciation of the tragedy of the event was shown by Lagrange in his lament to Delambre over the loss of their friend, "It required but a moment to cut off his head and perhaps a hundred years will not suffice to produce another like it." His execution has been called the "greatest crime of the Revolution." This scene has no foundation in fact. Lavoisier voluntarily surrendered himself after he learned that his fellow férmiers géneraux had been taken into custody.

ANTOINE LAURENT LAVOISIER.

Statue by Jules Dalou in the Musée du Luxembourg.

This statue formed a part of the French National Exhibit at the San Francisco Fair, 1915.

JOSEPH ACHILLE LE BEL: 1847–1930.

Announced the theory of the asymmetric carbon atom (1874) simultaneously with van't Hoff and the theory is equally credited to each. Pasteur, van't Hoff and Le Bel may be regarded as the founders of stereochemistry. Showed that the replacement of a radical in an optically active compound by a radical already present destroyed the optical activity. Le Bel was the first to take advantage of the selective action of microorganisms on the laevo and dextro isomers in separating an optically active component from an inactive mixture. Showed the formation of higher alcohols of glycol by fermentation and the dimorphism of the chlorides of platinum (1893). Sought the asymmetric nitrogen atom by preparing isobutyl-propyl-ethyl-methyl-ammonium salts (1900) and studied the stereochemistry of nitrogen. Le Bel held no academic position but carried on his researches privately. A wealthy individualist, he mingled but little with his colleagues. Received the Davy Medal, 1893.

NICOLAS LEBLANC: 1742–1806.

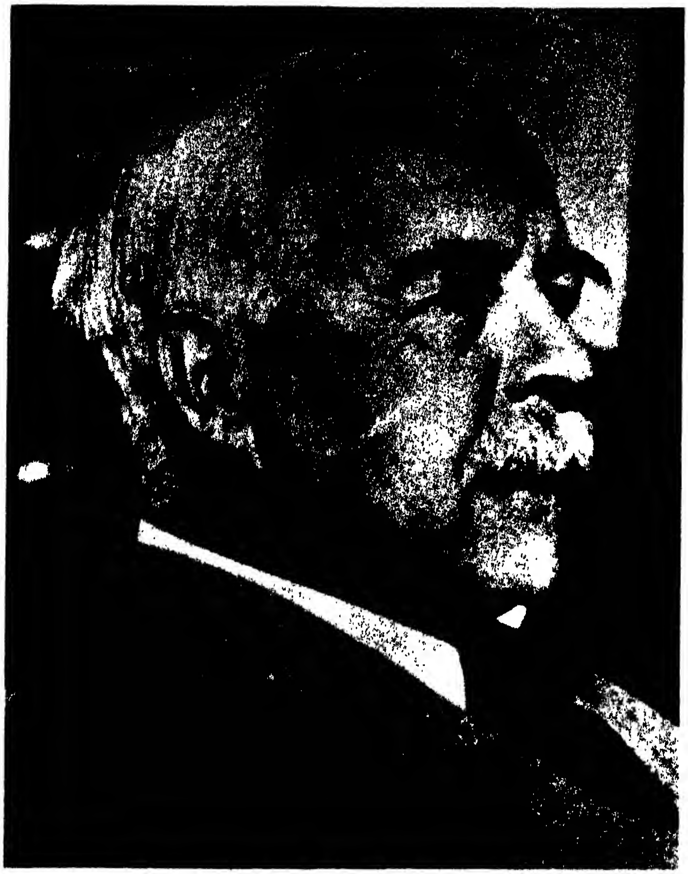
Pupil of Darcet and Rouelle. Friend of Fourcroy and Vauquelin. Physician to the Duke of Orleans. The growing need of soda in France led the Academy of Sciences to offer a prize for a commercial method for the production of soda from salt. Leblanc began his experiments in 1789, received patents in 1791, and borrowed funds of the Duke of Orleans to establish a factory. During the Revolution the Duke was beheaded (1793), the factory was confiscated and patents annulled (1794). After the Revolution Leblanc endeavored to regain his property but was unsuccessful. Broken in mind and body, penniless and his wife ill, Leblanc shot himself in the poorhouse of St. Denis. Even his grave is unknown. In 1887 a monument was erected to his honor at the Conservatoire des Arts et Métiers, Paris, and also at St. Denis.

HENRI LeCHATELIER: 1850–1936.

Professor at the École des Mines (1877), Collége de France (1898), and Sorbonne (1908). His investigations embraced the formation of minerals, including the setting of cement and plaster of Paris, allotropism and the principles involved in the metallurgy of the blast furnace. He is best known, however, for his studies in chemical mechanics and his establishment of the laws of chemical equilibrium known by his name throughout the scientific world. Invented a double galvanometer, a metallic microscope and a thermoelectric pyrometer. Established the "Revue de Metallurgie" (1904). Succeeded Moissan at the Sorbonne. Received the Davy Medal, 1916.

NICOLAS LEMERY: 1645–1715.

A French pharmacist who though not an original investigator was a good experimenter and possessed a scientific attitude of mind in advance of his time. He regarded chemistry as a demonstrative science and held that it was best taught by experiment. His "Cours de Chymie" (1675) held an influential place in chemistry for many years, passing through thirteen editions and being translated into all the principal languages of Europe. In this work he described the chemistry of the period in simple and clear language in marked contrast to the mystical phraseology of the writers of his time.



GILBERT NEWTON LEWIS: 1875–1946.

After graduating from Harvard studied with Ostwald and Nernst. Professor at the Massachusetts Institute of Technology (1905) and the University of California (1912). His work was in the field of chemical thermodynamics, free energy, equilibrium reactions, structure of the atom and molecule and theory of valence. His book, with Randall, "Thermoaynamics and Free Energy of Chemical Substances," was widely translated and his "Valence and the Structure of Atoms and Molecules" introduced his theory of valence electrons. Received the Davy Medal (1939).

CARL LIEBERMANN: 1842–1914.

Pupil of Bunsen and Baeyer. Professor at the Technische Hochschule, Charlottenburg. His name is forever linked with that of Graebe in the synthesis of the dye alizarin (1869) which was the foundation-stone upon which the German dye industry was erected. His investigations lay in the field of the derivatives of naphthalene, anthracene and various natural and artificial dyes and in the field of the alkaloids. For forty-seven years he contributed the results of his researches to the German Chemical Society. Received the Perkin Medal, 1906.

JUSTUS LIEBIG: 1803-1873.

A pupil of Gay-Lussac and professor at Giessen (1824) at the age of twenty-one, and Munich (1852). He constructed one of the first laboratories in Europe given over to experimental instruction in chemistry and so famous did this laboratory become that it was known as "a factory for the production of professors." He worked on fulminates with Gay-Lussac and studied the benzoyl radical which led to the theory of "radicals." Investigated the polybasic acids and worked on alkaloids and amides. He later became interested in agriculture and showed the necessity of certain elements as plant food in the soil. Developed the extraction of meat juices and laid the foundation of food and agricultural chemistry. His combustion method of determining hydrogen and oxygen in organic compounds is still employed. His contagious enthusiasm, his commanding personality and the vigor of his literary style made his influence felt in every department of the science but also brought him into controversies and much bitterness with others. Liebig's energy and application are perhaps best illustrated by a remark reported by Kekulé who had come to work in Liebig's laboratory, "If you plan to be a chemist you must be prepared to ruin your health by hard study; nothing less will produce anything." Founded "Annalen der Chemie" (1832).

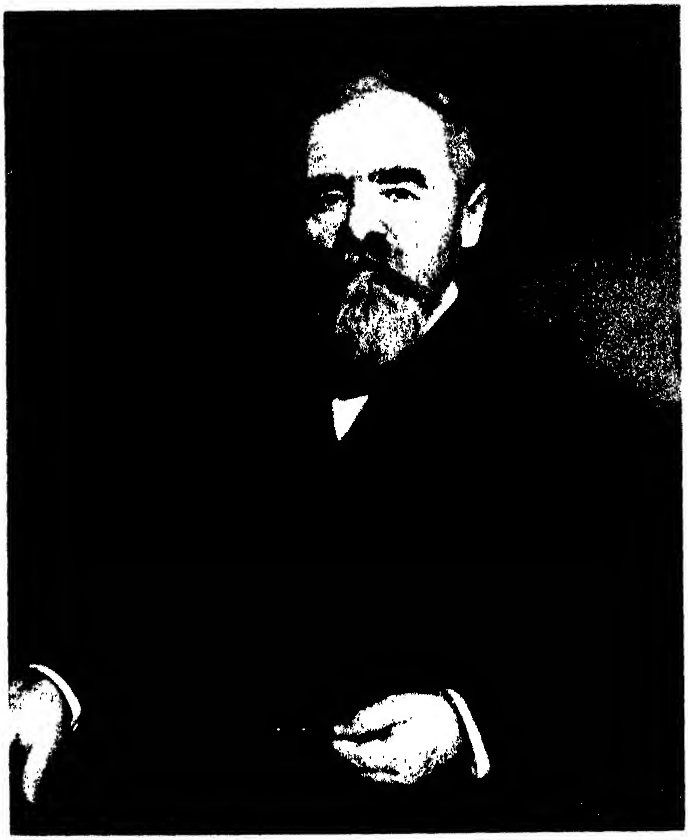
LIFE IN LIEBIG'S LABORATORY IN GIESSEN IN 1842.

Liebig established in Giessen in 1824 one of the first laboratories in Europe where systematic practical instruction in chemistry was given. Because of its far-reaching effects this may be regarded as the greatest of Liebig's many great accomplishments.

1. Ortigoso. 2,3. Unknown. 4. Keller. 5. Dr. Will, assistant to and successor of Liebig. 6. Strecker, later professor at Tübingen and Würzburg. 7. The janitor. 8. Wydler. 9. Varrentrapp, known for his method of nitrogen determination. 10. Scherer. 11. Unknown. 12. Böckmann. 13. A. W. Hofmann, later professor at Berlin and founder of the German Chemical Society.

STUDENTS AT LIEBIG'S LABORATORY IN GIESSEN IN THE EARLY FORTIES.

Fresenius Will Bullock Gardiner von Hofmann

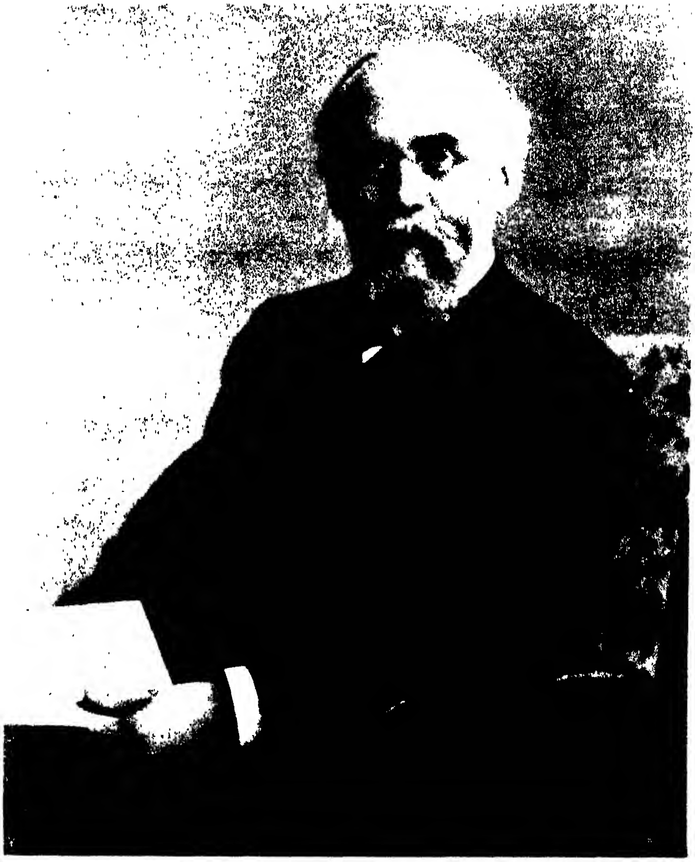


CARL VON LINDE: 1842–1934.

Professor of Applied Thermodynamics at the Technische Hochschule, Munich. Independently (1895) Hampson in England and Linde in Germany successfully attempted the liquefaction of gases by means of the Joule-Kelvin effect. Linde established (1895) the first plant for liquefying air by this principle and a machine for the production of oxygen (1896). In 1901 Linde obtained oxygen on an industrial scale by the fractional distillation of liquid air. It is due to his application of thermodynamics that the widespread use of oxygen in the industries today has been made possible.

MICHÁIL VASÍLIEVÍC LOMONÓSOV: 1711–1765.

A Russian scientist whose ideas were fully a century ahead of his time. He was the precursor of Lavoisier in the introduction of quantitative methods of investigation and like him studied the calcination of metals in sealed vessels. He, too, found no increase in weight of the vessel after calcination and drew the correct conclusion that the augmented weight of the metal was due to its combination with the air. He had a clear insight into the constitution of matter; anticipated the kinetic theory of gases; made the earliest demonstration of the law of the conservation of mass during chemical change. He built the first chemical laboratory in Russia (1749), which was the first in the world, where students were instructed in chemistry by the laboratory method. He was made Secretary of State in 1764 and occupies an important place in the history of Russian literature.



HENDRIK ANTOON LORENTZ: 1853–1928.

Professor at Leyden and Director of the Teyler Institute at Haarlem. Outstanding mathematical and theoretical physicist. His contributions were in thermodynamics and relativity of the earth's motion to the ether. Received the Rumford (1908) and the Copley (1918) medals and the Nobel Prize (1902), with P. Zeeman, for researches on the influence of magnetism upon the phenomena of radiation.

THADDEUS LOWE: 1832–1913.

Invented the carburetted water-gas process (1873), now so generally used for metallurgical heating and illuminating purposes. Invented a compression ice machine and made the first artificial ice in the United States (1865). As early as 1856 he constructed balloons to study atmospheric phenomena and during the war between the States was Chief of the Aeronautic Corps and in 1862 generated gas on the battlefields of Yorktown and Fair Oaks for observation balloons. Invented the Lowe coke oven (1897).

GEORG LUNGE: 1839–1923.

Professor at Zurich where he taught for thirty-two years, drawing to his laboratories students from all countries. He spent twelve years (1864–1876) in the rapidly expanding chemical industry of England where he soon became a leader in the production of heavy chemicals. Prepared one hundred per cent sulfuric acid by the freezing method and explained the reaction in the lead chamber as due to nitrosylsulfuric acid. Many of the specific gravity tables of solutions of acids, bases and salts still in use were prepared under his direction. Introduced the use of methyl orange as an indicator in the analysis of alkali carbonates and the Lunge nitrometer has been of untold service in the determination of gaseous volumes liberated in a reaction. His "Handbuch der Soda-Industrie" (two volumes, 1879), "Steinkohlenteer und Ammoniak" (two volumes, 1867), and "Chemisch-technischen Untersuchungsmethoden" (four volumes, 1910) all passed through many editions and appeared in many translations. His leadership was due to his amazing power of employing every moment to the fullest.

JANE MARCET: 1785–1858.

Author of "Conversations on Chemistry." The first edition appeared about 1805 and other editions followed until 1853, and during this time more than 160,000 copies were sold. Faraday wrote to his friend De la Rive, "Mrs. Marcet's Conversations on Chemistry gave me my foundations in that science . . . you may imagine my delight when I came to know Mrs. Marcet personally . . . how often I think of my first instructress." Faraday always sent Mrs. Marcet copies of his publications. Edgar Smith wrote "Chemists will ever revere Mrs. Marcet's memory. For their science and her science she performed a noble, never-to-be-forgotten service."

ANDREAS SIGISMUND MARGGRAF: 1709–1782.

Director (1767) of the Academy of Science, Berlin. Last and most eminent adherent of the phlogistic theory in Germany. Discovered sugar in the beet (1747); introduced the use of the microscope in chemistry; distinguished alumina from lime (1754); estimated silver as silver chloride, and knew the flame tests for the alkalies. His exceptional gift of observation put him in a position to carry out researches of the greatest value. He noted the increase in weight of phosphorus on oxidation but could not free himself of the idea that phlogiston escaped during the process; in other respects he drew sound conclusions from his observations.

JEAN CHARLES GALISSARD DE MARIGNAC: 1817–1894.

Professor at Geneva where for thirty years he worked under most unfavorable conditions, producing most valuable results. His work on the atomic weights of twenty-eight elements was the most accurate of his time. At the age of twenty-four he began the study of the rare earths which he continued throughout his life. Separated ytterbia from what was supposed to be pure erbia, isolated gadolinia and samaria; proved tantalum and niobium are not identical. Proved the formula of silicon dioxide which revolutionized chemical mineralogy. His study of the complex silicates clarified this confused chapter. "Modest, patient and unassuming, he lived wholly for science." Received the Davy Medal in 1886.

JOHN MAYOW: 1645–1679.

English physician and scientist at Oxford. Showed there was a substance in the air which took part in the calcination of metals (1668). He also showed that in respiration a part of the air was used up while the remainder was insoluble in water, did not support combustion and was lighter than the original air. He came astonishingly close to preceding Lavoisier's theory of combustion by a full century.

DIMITRI IVANOVITSCH MENDELÉEFF: 1834–1907.

Professor of Organic Chemistry at the University of St. Petersburg (Petrograd) 1866. Although he did much work on the physical properties of gases and liquids he is best known for his discovery of the periodicity of the physical and chemical properties of the elements and their atomic weights. From a study of his tables of the atomic weights of the elements and their properties Mendeléeff predicted (1869) the discovery of three unknown elements and their chemical and physical properties and made corrections in the atomic weights of other elements. The unknown elements that he predicted he called *ekaboron*, later discovered by Boisbaudran (1875) and named Gallium; *ekaaluminum*, discovered by Nilson (1879) and named Scandium; and *ekasilicon*, discovered by Winkler (1886) and named Germanium. Lothar Meyer made, simultaneously and independently, similar discoveries between the atomic weights and the properties of the elements. Mendeléeff and Meyer were awarded the Davy Medal jointly in 1882. His two-volume "Principles of Chemistry" is a chemical classic.

LOTHAR MEYER: 1830–1895.

Professor at Karlsruhe (1868) and Tübingen (1876). Co-founder of an epoch in chemistry. From his study of the properties of the elements and their compounds he was led to the discovery of the periodicity of the elements and by one of those curious co-incidents his discovery was simultaneous with that of Mendeléeff (1869). His books "Die Modernen Theorien der Chemie" and "Grundzüge der Theoretischen Chemie" passed through many editions and were translated into English, French and Russian. Lothar Meyer's name occupies a foremost place in the development of Theoretical Chemistry. Awarded the Davy Medal with Mendeléeff, 1882.

VICTOR MEYER: 1848–1897.

Studied under Bunsen, Erlenmeyer and Kopp. Professor at Zurich (1872) at the age of twenty-four, Göttingen (1885) and Heidelberg (1889). Investigated the nitro compounds of the paraffin series; iodo, iodoso, and iodonium compounds (1895); explained the stereoisomerism of the oximes (1883); discovered thiophene (1883); developed the vapor density method known by his name (1878); and showed the dissociation of the iodine molecule with rise of temperature. The discovery of thiophene was due to a failure of a lecture table experiment of Meyer's. An accepted test for benzene had always been a blue color with isatin in sulfuric acid but in the lecture experiment no blue color appeared. On investigation Meyer found that a synthetic benzene had been used and reasoned that the common coal-tar benzene must contain a new substance. Within a few hours he started a search for this substance with the result of the discovery of thiophene and all its analogous benzene compounds. A brilliant lecturer; an inspiring teacher; a worthy successor of Bunsen, and one of the outstanding organic chemists of his time.

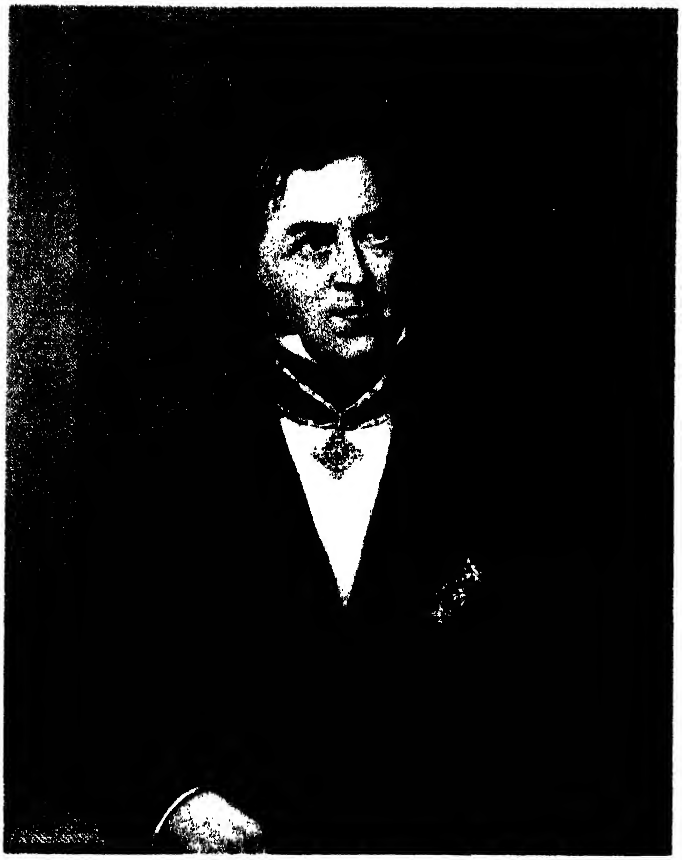
Meyer prepares a dynamite cartridge before his class —

and explodes it in a block of wood under a packing case.

VICTOR MEYER'S LECTURE TABLE.

ALBERT ABRAHAM MICHELSON: 1852–1931.

Came as an immigrant child to America from Posen. Graduate of U. S. Naval Academy, where he taught physics and chemistry from 1875 to 1879. Professor at Case School (1881), Clark (1889) and Chicago (1892) Universities. During a period of fifty-one years (1880–1931) he made ten series of measurements of the speed of light. His last set of measurements were completed by his assistants as he lay on his death-bed. In this series he used a welded vacuum tube three feet in diameter and a mile long buried in the earth. His measurements led to experiments on ether-drift (1887–1928) and to the theory of relativity. Developed the interferometer by which he gave the exact length of the meter and measured the diameter of the fixed stars. Measured the rigidity of the earth (1916). Developed the U. S. Naval range finder. Received the Rumford Medal (1889), the Copley Medal (1907) and the Nobel Prize (1907).

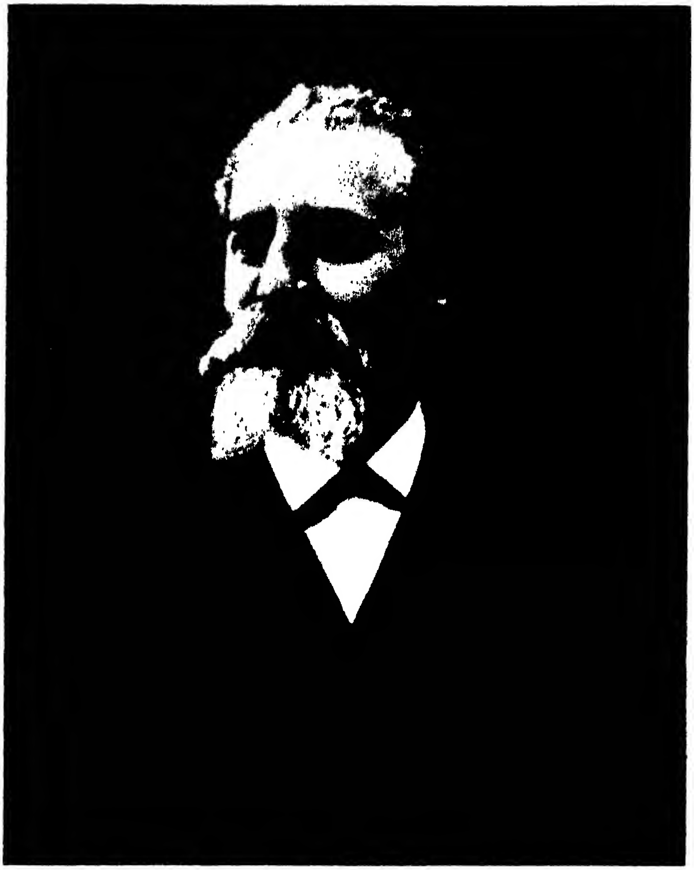


EILHARD MITSCHERLICH: 1794–1863.

Professor at Berlin (1821). Mitscherlich is best known for his discovery of isomorphism and dimorphism and the relationship between chemical compositions of crystalline form and the bearing of isomorphism on the determination of the atomic weights. He discovered selenic acid and found that its salts are isomorphous with the sulfates. He improved the accuracy for organic and inorganic analysis, studied manganic and permanganic acids and worked with the decomposition products of benzoin and benzaldehyde. Discovered nitrobenzene (1833), monoclinic sulfur (1823). Early recognized the existence of catalysis, which he called "contact action."

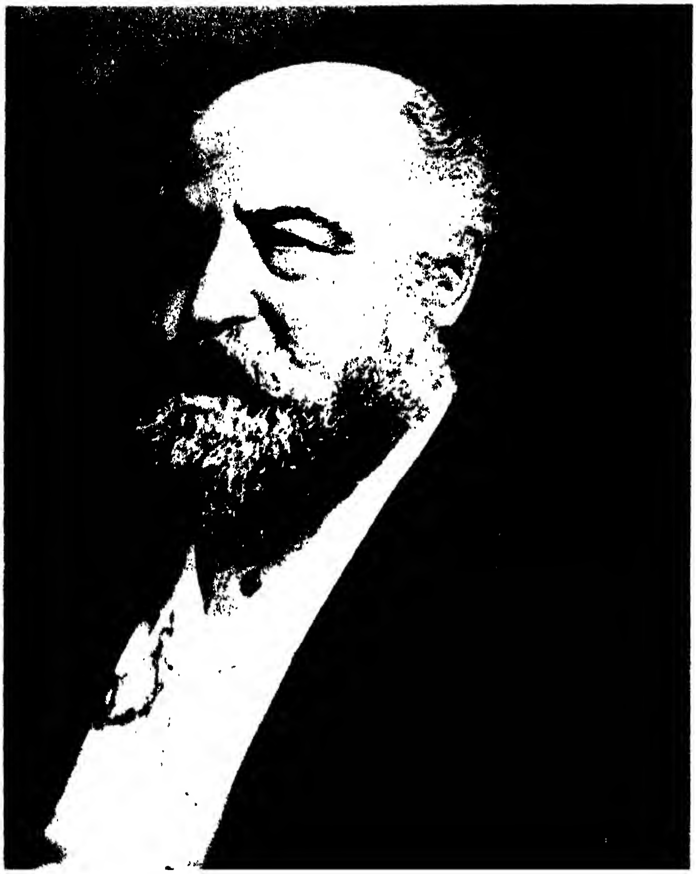
KARL FRIEDRICH MOHR: 1806–1879.

Professor at Bonn. He was of great service to analytical and pharmaceutical chemistry especially in the field of volumetric analysis. He was first to use oxalic acid in alkalimetry and chromic acid as an indicator in the determination of the halogens. His text-books were many and widely used and passed through many editions. His ideas on the different forms of energy and their mutual connection (1837) brought him close to the discovery of the Law of the Conversation of Energy announced by Joule (1842). The pinch-clamp, the cork-borer, the specific-gravity balance and Mohr's salt ($(NH_4)_2Fe(SO_4)_2$) are daily reminders of Mohr.



FERDINAND FRÉDÉRIC HENRI MOISSAN: 1852–1907.

Professor at the University of Paris. Isolated fluorine (1886), liquefied it (1887) and prepared many of its compounds. Pioneer in the use of the electric furnace (1892). Synthesized the ruby and made artificial diamonds (1893). Reduced many oxides, including those of uranium, chromium, and tungsten. Prepared many carbides, nitrides, borides and hydrides. The results of his work are seen today in several great industries, but the promotion of pure science was his objective. Founder of the chemistry of high temperature and one of the most gifted of experimental chemists. Received the Nobel Prize, 1906. A monument in his honor has been erected in Meaux, near Paris.



LUDWIG MOND: 1839–1909.

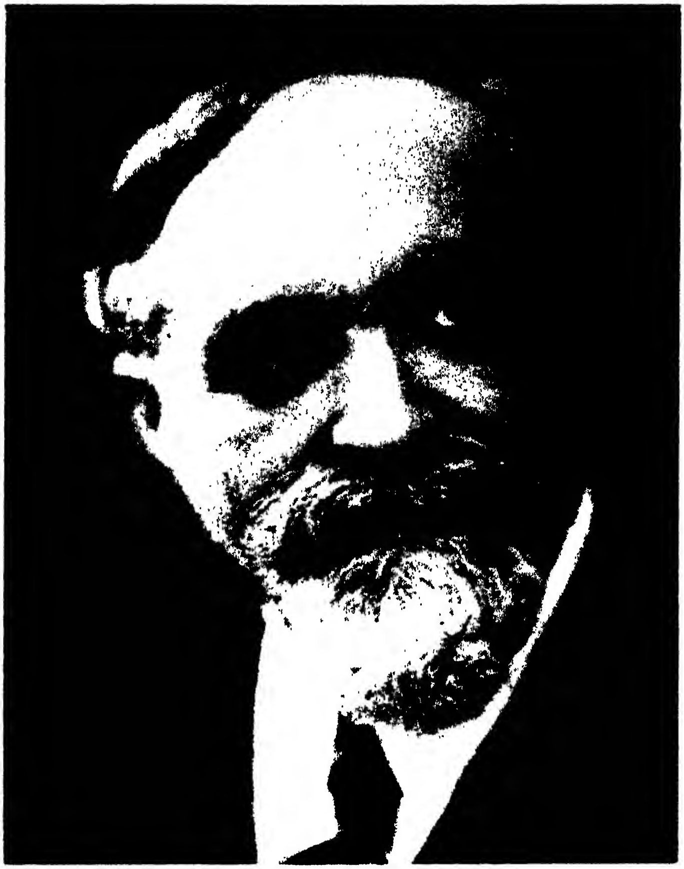
An industrial chemist, born in Germany; pupil of Kolbe and Bunsen. Lived most of his life in England where he established the Solvay Process (1873). The difficulties in the development of the process kept him at the factory day and night for weeks at a time, securing what sleep he could in his office chair. To obtain cheaper ammonia he turned to gas manufacture and developed "Mond-gas," essentially a producer-gas. His discovery of the nickel and iron carbonyls led to the Mond Process for the recovery of nickel from its ores, yielding a metal 99.9 per cent pure. He shared his great fortune generously with various scientific institutions.

EDWARD WILLIAMS MORLEY: 1838–1923.

Professor at Western Reserve University. His investigations included the determination of the percentage of oxygen in the air, the thermal expansion of gases and metals, the velocity of light, the relative motion of the earth and the ether, the composition of water, and the relative weights of hydrogen and oxygen. This last investigation occupied thirteen years (1882–1895). His final values agreed to 1 part in 10,000 and gave the ratio of oxygen to hydrogen as 16–1.008, which ratio has since been accepted throughout the chemical world. His skill in the detection and elimination of constant sources of error, his great patience in the purification of his materials, and his perseverance in overcoming obstacles mark his consummate thoroughness. His studies on the syntheses of water constituted a rigorous test of the law of conservation of mass. "Such men are rare jewels in any nation's crown."

HENRY GWYNN JEFFERYS MOSELEY: 1887–1915.

Studied under Rutherford at Manchester. Carried on his own researches at Oxford. His name will ever be associated with the discovery of the Law of Atomic Numbers (1914). By employing the X-ray crystal lattice of Laue and using different elements as the anticathode he measured the wavelengths of the elements and found that whole numbers can be assigned to each element which are inversely proportional to the square roots of the wavelengths of the corresponding lines in their X-ray spectra. These atomic numbers are more fundamental than atomic weights and represent the nuclear charge on the atom of each element. This discovery cleared away the irregularities which had persisted in Mendeléeff's table and placed the elements of the rare earths in proper sequence. It showed the range of the elements to be from one to ninety-two with but two remaining undiscovered at the time. Moseley was but twenty-six years old when he announced this fundamental discovery. He was killed while engaged with the ill-fated British expedition at the Dardanelles.



CHARLES MOUREU: 1863–1929.

Professor at the Collège de France. Studied the unsaturated hydrocarbons and the derivatives of acetylene. Established the constitution of eugenol and isosafrol and investigated many of the essential oils. Formulated an hypothesis to explain antioxidation. This study led to the present-day use of antioxidants in the rubber and vegetable oil industries. His investigations of the condensation products of acrolein also bore fruit in the industrial field. Discovered rubene which acts with oxygen like haemoglobin of the blood. Studied the presence of the rare gases in wells and mines.

WILLIAM MURDOCK: 1754–1839.

First to show the practical use of coal gas for illuminating purposes. In 1792 he lighted his home with gas distilled from coal in an iron retort. In 1798 he installed an arrangement for lighting a factory in London and in 1804 he built a gas works for a cotton mill in Manchester for which he was awarded the Rumford gold medal (1808). Westminster Bridge was lighted in 1813, Paris streets in 1820. In the United States Baltimore had the first gas lighting (1816); Boston, 1822; New York, 1823.

WALTHER H. NERNST: 1864–1941.

Professor at Göttingen (1891) and Berlin (1905). One of the leaders in the creation of Physical Chemistry. Studied solutions and the dissociation of pure water. With Ostwald and Arrhenius he collaborated in the theorem of the electromotive activity of the ions. Introduced (1889) the important theory of solubility product in connection with precipitation reactions. His study of the behavior of matter on the approach to absolute zero led to his third law of thermodynamics. Invented the "Nernst lamp" made with a metallic filament (1898). Received the Nobel Prize, 1920, for his work in thermochemistry.

SIR ISAAC NEWTON: 1642–1727.

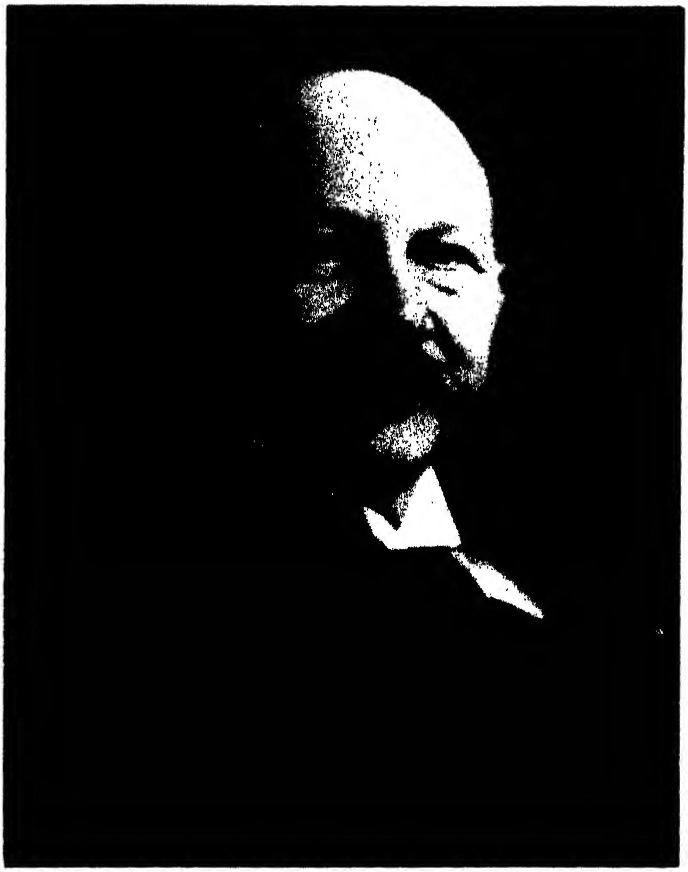
Mathematician and Professor at Trinity College, Cambridge (1669). Discovered the binomial theorem (1665) and later integral calculus. Began his calculations on the effects of gravitation on the orbit of the moon in 1665, but the corrected and developed theory appeared in his great work known as the *Principia* in 1687. Constructed the first reflecting telescope (1668). Explained the colors shown by thin plates and still known as Newton's rings (1675). Explained the colors of the spectrum as due to difference in wavelengths of light. His researches on light and color were published in his *Optics* (1704). Newton devoted much of his time to the study of chemistry but the greater number of his experiments still remain in manuscript. His *Tabula Quantitatum et Gradium Caloris* contains a comparative scale of temperature from that of melting ice to that of coal fire. A chemical paper *Natura Acidorum* was published by Dr. Horsley. He spent much time studying the work of the alchemists. Newton expounded his belief that physical and chemical properties were explainable on the basis of strong attractions between the ultimate particles of composing substances. Knighted by Queen Anne (1705).

LARS FREDRIK NILSON: 1840–1899.

Professor at Upsala (1878) and Stockholm (1883). Determined the atomic weight and specific heat of beryllium and showed its proper place in the periodic system; the result gave great support to the new classification of the elements by Mendeléeff and Lothar Meyer. In 1879 he discovered the element "eka-boron" predicted by Mendeléeff and named it Scandium in honor of his native country. Prepared pure thoria (1883) and isolated ytterbium. Showed that indium had three chlorides. With Petterson he obtained titanium (1887), though in an impure state, by reducing the chloride with metallic sodium in a steel bomb. His work on the rare earths did much to clarify a confused subject.

ALFRED NOBEL: 1833–1896.

Born in Stockholm; an industrialist and inventor. Stabilized nitroglycerine by absorbing it in kieselguhr (1862) and thus made possible its safe use as dynamite. Established the first factory for the manufacture of dynamite (1866). Invented blasting gelatine, a colloidal solution of nitrocellulose in nitroglycerine (1875). Introduced "ballistite," a smokeless nitroglycerine powder (1887), which was the first of the smokeless powders used by the European armies. He held three hundred and fifty patents including substitutes for rubber, silk and leather. He had poor health all his life and never married. He was simple in all his tastes though he amassed great wealth. He left his fortune to establish prizes in Science, Literature and Peace.



HEIKE KAMERLINGH ONNES: 1853–1926.

Professor at Leyden (1882). Founded the famous Cryogenic Laboratory in Leyden and began the study of low temperatures (1894). The triumph of his career came in 1908 when he succeeded in liquefying helium and attained a temperature of probably 0.9° Abs. Although his attempts to solidify helium were unsuccessful this goal was accomplished in his laboratory by his successor Keesom in 1926. A biographer writes, "One of the most genial, kind-hearted and accessible men who ever lived . . . to young men he was an inspiration . . . his scientific memory is imperishable." Received the Rumford Medal (1912) and Nobel Prize (1913).

WILHELM OSTWALD: 1853–1932.

Professor at Leipzig (1887) and a teacher of renown, whose laboratory was a Mecca for students in Physical Chemistry during the nineties. He early became a supporter of Arrhenius's ionization theory and became its great protagonist. The work carried out under his supervision through a period of two decades included studies of osmotic pressures, boiling and freezing points, electromotive forces, oxidation and reduction cells and supersaturated solutions, to name but a few. He founded and edited the "Zeitschrift für physikalische Chemie" (1887) and was the author of many famous textbooks. In 1900 he discovered, during his work on catalysis, a method of oxidizing ammonia to form oxides of nitrogen. This method when carried to industrial scale supplied Germany with her much needed nitrates during the World War. In his later years Ostwald wrote much on philosophy and color theory. He received the Nobel Prize in 1909 for his work on catalysis, and the fundamental principles governing chemical equilibrium and rates of reaction.

BERNARD PALISSY: 1510–1589.

"A worker in clay" he called himself. Developed the art of glazing pottery and the production of faience in France. For sixteen years he suffered continuous failure and at one time was compelled to burn his furniture and the floors of his house in order to keep up the fires in his kiln. Finally he triumphed. He received the support of the nobility and Catherine de Medicis became his patron. He set up his kiln in Paris and his clay bed was close to where the Louvre now stands. Although a Protestant, Catherine saved him from the massacre of Saint Bartholomew's Eve, but he later fell a victim to religious hatred and the archives record "on July 4, 1589, Bernard Palissy was hanged, strangled, and his body burned to a cinder. For his heresy was this done." According to some accounts he died in the Bastille. Specimens of his faience are to be seen in the Louvre and Cluny Museums. "Son of an artisan he became the protégé of kings."

PHILIPPUS AUREOLUS PARACELSUS THEOPHRASTUS BOMBASTUS. EREMITE OF HOHENHEIM: 1493–1541. Usually known as PARACELSUS.

Born in Switzerland; one of the most picturesque personalities of the Renaissance. For many years, like many other physicians of his time, he roamed through Europe picking up a little knowledge here and there along with many bad habits. Although a mixture of physician and quack he revolted against the medical practice of the time and taught that disease must be treated by experimental use of chemicals accompanied with observation. In 1527 he became Professor of Medicine at Basel but was soon forced to retire. In spite of his foibles and bombast he had a keen mind and did much to correct the low level into which medicine had fallen.

THE ALCHEMICAL MAKING OF A MEDICINE IN THE SIXTEENTH CENTURY.
A painting by Michael Z. Diemer in the Deutsches Museum, Munich.

The painting shows the consulting doctors, the patient, the herb gatherers, and the furnace for distilling the herbs. During the Middle Ages medicine was in a pitiful state; most remedies were loathsome decoctions of herbs and putrid matter and the more revolting the mess the more potent the medicine was believed to be. Following the attacks upon the practices of the doctors of his time by Paracelsus (1493–1541) there developed a new branch of chemistry, iatrochemistry, wherein the main object of the alchemist was not the production of gold but the search for the Elixir of Life. This led to the discovery of many new compounds and thus extended the knowledge of chemistry.

ANTOINE AUGUSTIN PARMENTIER: 1737–1813.

An apothecary in Paris. Supporter of Lavoisier's theory of combustion. He did much to improve French agriculture by scientific studies and was especially interested in the cultivation of the potato and in extending its consumption in France where at the time it was not popular. Like Rumford he was interested in the study of nutrition. Published "Rural and Domestic Economy" (eight volumes).

LOUIS PASTEUR: 1822–1895.

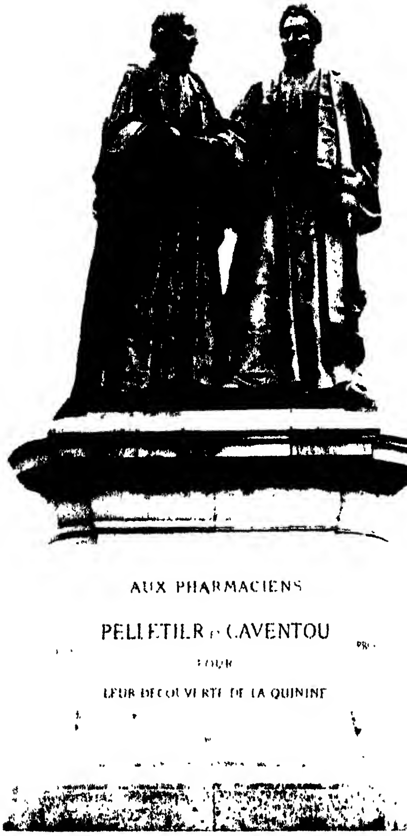
Professor at Lille (1854) and École Normale, Paris (1857). French chemist and bacteriologist. Pasteur's early work upon the tartaric acids revealed to chemists for the first time the relationships now spoken of as optical isomerism. This has now become one of the more important chapters of the science. Later his work on fermentation laid the foundations of bacteriology and taught its use in detecting and combating disease. Saved the silkworm industry for France (1868), carried on a successful campaign against the cattle disease, anthrax, and introduced inoculation against hydrophobia. Few scientists have by their research done so much to prolong human life and alleviate human suffering. The Pasteur Institute erected by popular subscription was the scene of his researches from 1889 on.

LOUIS PASTEUR.

Caricature of Pasteur by "T" entitled "Hydrophobia" appearing in *Vanity Fair* as a colored supplement, January 8, 1887.

EUGÈNE MELCHIOR PÉLIGOT: 1811–1890.

Professor at the Conservatoire des Arts et Métiers as successor of Dumas. Worked on cinnamic acid and on the cinnamyl radical (1834). Helped establish the composition of alcohols, described methyl fluoride and used phosphorus pentachloride for chlorination (1836). Determined the atomic weights of uranium and chromium. Isolated the metal uranium by reducing the chloride with metallic potassium and showed that the uranium prepared by Klaproth fifty years earlier was really uranous oxide, UO_2. In technical chemistry he did much to improve the beet sugar industry and the manufacture of sulfuric acid. He was a director of the French Mint (1846).

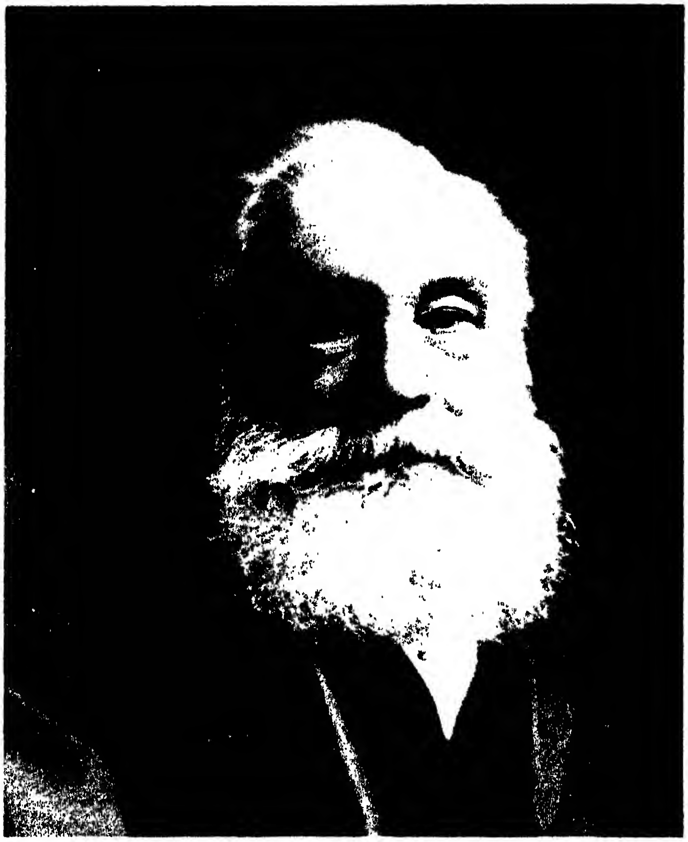


PIERRE JOSEPHE PELLETIER: 1788–1842.

Professor at the École de Pharmacie, Paris. Discovered strychnine (1818), brucine (1819), cinchonine (1821) and caffeine (1821). With Joseph Caventou (1795–1877) he discovered quinine in cinchona bark (1820) and prepared it in a pure state. By this discovery these scientists became benefactors to humanity for they made possible the preparation of prescriptions of known strength for medical use. In recognition of their work the French Academy gave them a prize of ten thousand francs and Tanret named an alkaloid "pelletierine" in his honor. The monument stands on the Boulevard St. Michel, Paris.

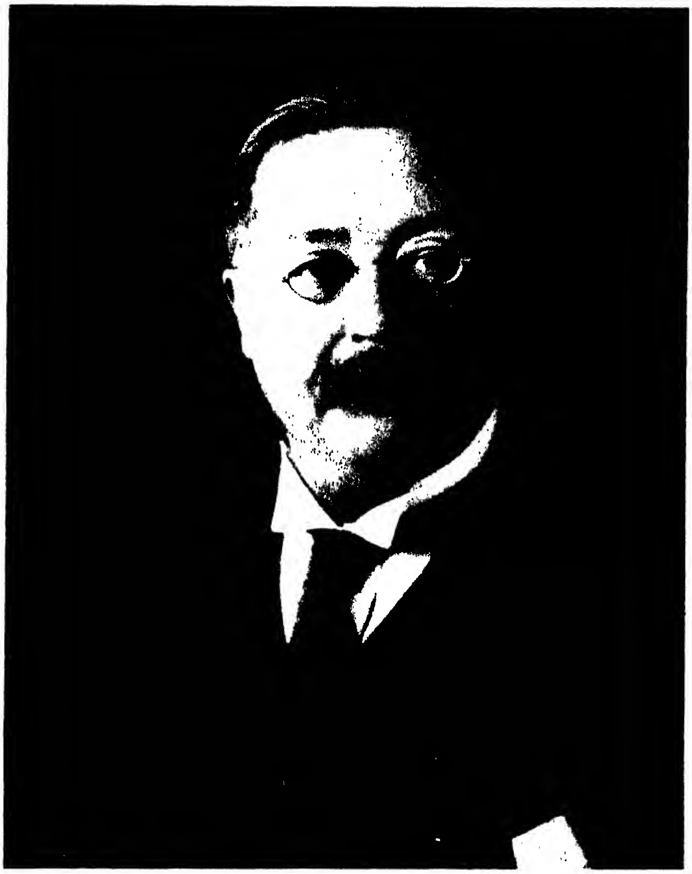
THÉOPHILE JULES PÉLOUZE: 1807-1867.

Pupil of Gay-Lussac. Professor of Chemistry at the École Polytechnique and the Collège de France (1831). Director of the Mint (1848). Determined the atomic weight of arsenic, phosphorus, nitrogen, and silicon, studied pyrogallic acid and worked on the terpene series and the inorganic esters of alcohol. Prepared propionitrile (1834), the first of the nitriles; established the composition of glycerine (1836); discovered borneol (1841); improved the methods of plate glass manufacture (1856). Wrote a Treatise on Chemistry (six volumes).



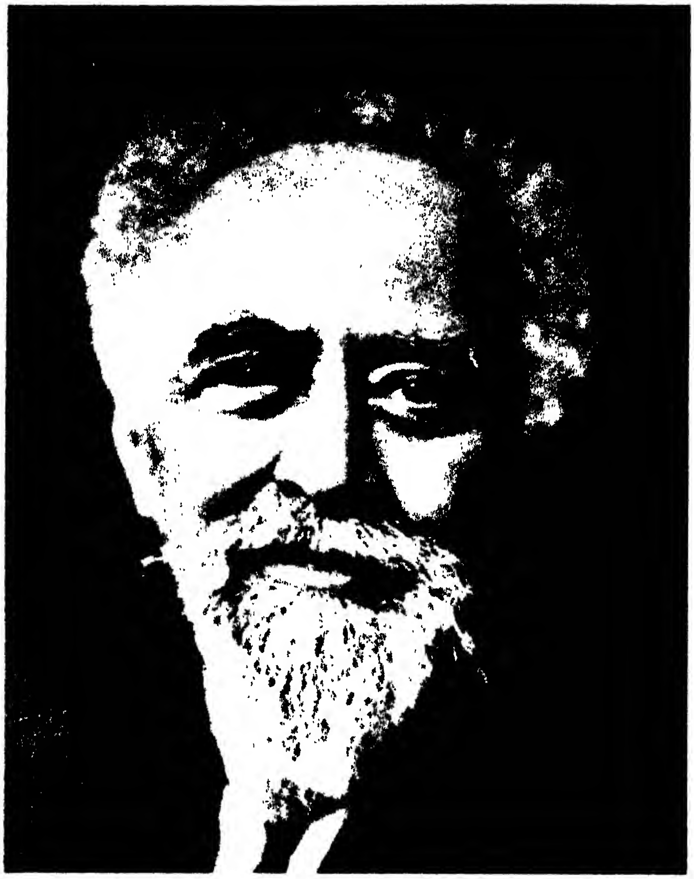
SIR WILLIAM HENRY PERKIN: 1838–1907.

A pupil of Hofmann at the Royal College of Chemistry, London. In 1856 by the oxidation of commercial aniline he succeeded in making the dye "mauve." This was the starting point of the coal-tar dye industry. Against the advice of Hofmann he withdrew from the Royal College and concentrated his abilities on developing the commercial aspects of his discovery. When the process had become fully established he sold his factory and returned to pure research. Perkin synthesized coumarin and cinnamic acid and developed a process for making artificial alizarin. The "Perkin reaction" for the preparation of unsaturated acids is widely used. In 1906, on the occasion of the fiftieth anniversary of the discovery of "mauve," Perkin received honors from chemical societies far and wide. He came to New York to receive the first imprint of the Perkin Medal established by the Society of Chemical Industry in his honor. This occurred at a formal dinner at Delmonico's and was attended by the leading chemists of the country all wearing dress ties of mauve color. He was knighted in 1906. His later researches dealt with magnetic rotatory power.



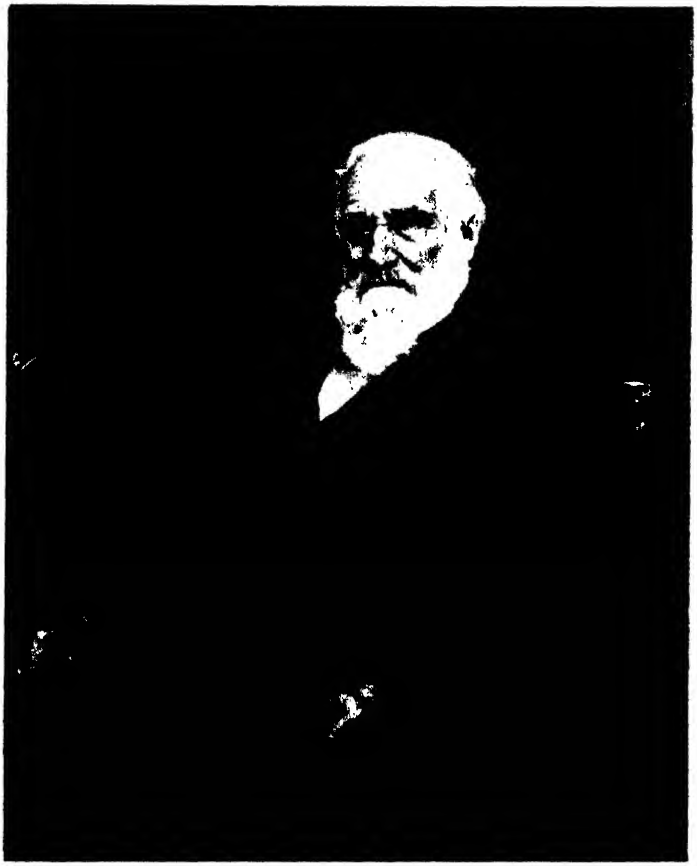
WILLIAM HENRY PERKIN, Jr.: 1860–1929.

Studied with Frankland, Wislicenus and Baeyer. Professor at Edinburgh (1887), Manchester (1892) and Oxford (1913). He inherited his interests in chemistry from his father, the founder of the coal-tar dye industry in England, and became one of England's outstanding chemists. His studies included the terpene series, the constitution of camphor and its derivatives and the synthesis and constitution of many alkaloids. Demonstrated the existence of three, four and five carbon atom ring compounds. In the field of stereochemistry he succeeded in separating a racemic mixture of a complex acetic acid derivative into optically active components. This was the first instance of an optically active carbon compound which did not contain an asymmetric carbon atom but whose optical activity was due to asymmetric molecular formation. Received the Davy Medal (1904) and the Royal Medal (1925).



JEAN BAPTISTE PERRIN: 1870–1942.

Professor of Physical Chemistry at the Sorbonne. He confirmed quantitatively that the Brownian movement is the result of molecular impacts and determined the magnitude of Avogadro's Number as 6.06×10^{23} by counting the reflections of various suspensions of minute particles as seen through a microscope. Received the Nobel Prize (1926) for his investigations on the discontinuous structure of matter and for his discovery of sedimentation equilibria.



MAX JOSEPH PETTENKOFER: 1818–1901.

Professor of Hygiene at Munich (1865). His interests were centered chiefly in food-chemistry and those problems bearing directly upon public health and nutrition. Though best known for his campaigns against typhoid and cholera, and for his efforts to secure a safe supply of water for Munich, this distinguished physiologist and hygienist was also a good applied chemist; he worked on glass, cement, wood, distillation, and restoration of paintings. In his interests on nutrition he constructed, with Voit, a respiration calorimeter in order to determine the relation between the oxygen consumed and the carbon dioxide produced by the animal body.

BARON LYON PLAYFAIR: 1818–1898.

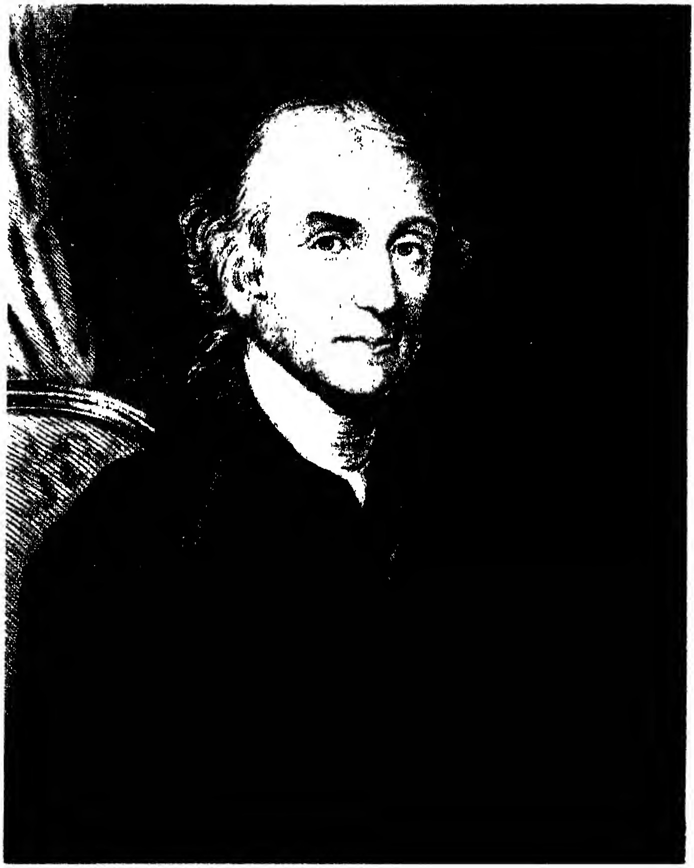
Educated at Glasgow; pupil of Liebig and professor at the London School of Mines and at Edinburgh. His contributions to science were more in focusing public attention on the importance of science in general, and chemistry in particular, and to the advancement of Labor, Technical Education and Public Welfare. Discovered nitroprusside (1849).

SIR WILLIAM JACKSON POPE: 1870–1939.

Pupil of Armstrong. Professor at Manchester (1901) and Cambridge (1908). Worked on the chemistry of camphor and the terpenes and on the stereochemistry of inorganic compounds. He showed the optical activity of asymmetric tin compounds and prepared asymmetric organic compounds of selenium and tellurium. These compounds of selenium and tellurium had such nauseating odors that the Cambridge city officials feared that a new sewage system just installed was a failure until the odors were traced to their source. Pope and his assistants proceeded to finish their research in a lonely meadow outside the city.

FRITZ PREGL: 1869–1930.

Professor at Innsbruck (1910) and Graz (1913). During an investigation of the bile acids he found that the materials he obtained were in such small amounts that it would be necessary to abandon this research or develop a new technique for analysis with much smaller amounts of materials. He chose the latter course and developed methods for the determination of hydrogen, carbon, nitrogen and organic groups employing from 3 to 5 mg. (1911–1918). He later extended his methods and founded the new science of microchemical analysis. Hundreds of investigators from all parts of the world flocked to the small university in the village of Graz to learn his methods. "He was an outstanding and original personality with fine human qualities." Received the Nobel Prize in 1923.



JOSEPH PRIESTLEY: 1733–1804.

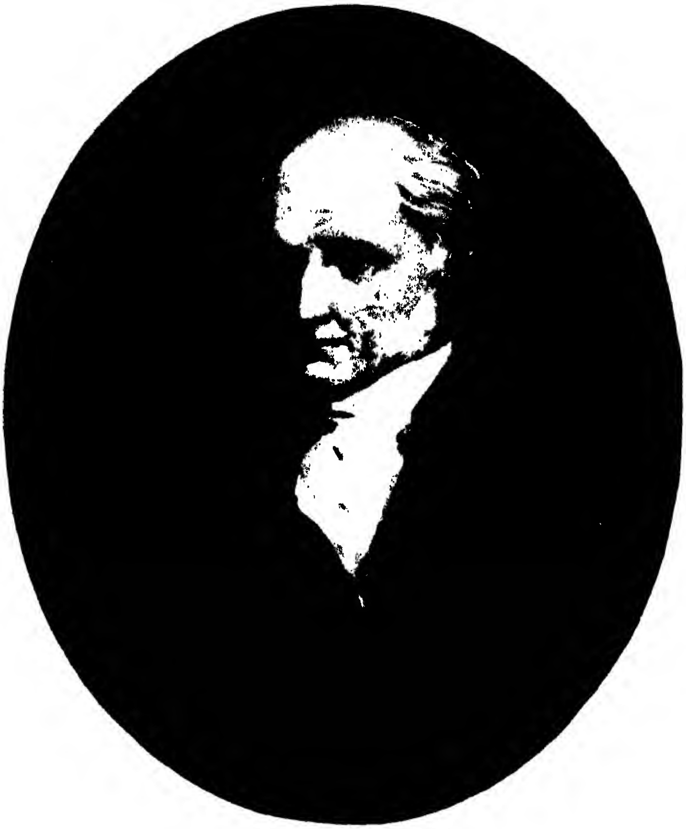
A liberal clergyman of Birmingham, England who experimented in chemistry and physics for his own entertainment. He discovered oxygen (1774) which he called dephlogisticated air and connected it with combustion and plant and animal metabolism. Although his discoveries were largely instrumental in bringing about the "Chemical Revolution," he held firmly to the doctrine of phlogiston. He was successful in obtaining new gases because he used mercury in his pneumatic trough. Among the gases he prepared were hydrogen chloride, ammonia, sulfur dioxide, nitrous and nitric oxides and silicon tetrafluoride. Persecuted in England because of his liberal religious views and because of his sympathy with the French Revolution he came to the United States in 1794 and settled in Northumberland, Pennsylvania. His reception in America was most cordial and his friends included Washington, Jefferson and Franklin. On the centennial of the discovery of oxygen a group of chemists met at Northumberland and founded the American Chemical Society. His home there is now a memorial.

THE SACKING OF PRIESTLEY'S HOUSE IN BIRMINGHAM: 1791.

Priestley was sympathetic with the French Revolutionists and openly critical of the Established Church in England. He became so unpopular that on the anniversary of Bastille Day (1791) a riot occurred and his house was sacked and his books and papers were destroyed. His church was burned to the ground and he and his family were forced to flee to London. In 1794 he abandoned England for the United States and settled in Northumberland, Pennsylvania.

JOSEPH LOUIS PROUST: 1754–1826.

Born at Angers, France; studied chemistry in his father's apothecary shop and with Rouelle in Paris: became Professor of Chemistry at Salamanca (1791) and Director of the Royal Laboratory at Madrid. In his controversy with Berthollet which lasted eight years (1799–1807), he established the Law of Definite Composition. His work also laid the foundations for the Law of Multiple Proportions later announced by Dalton.



WILLIAM PROUT: 1785–1850.

English physician and chemist. His name is forever associated with the hypothesis, which bears his name, that the atomic weights of the elements are multiples of that of hydrogen. This hypothesis he put forth anonymously in 1815 in two papers appearing in the *Annals of Philosophy*. The authorship of the papers was later acknowledged to be that of Dr. Prout. The thought appealed to the chemists of the time and in spite of the work of Stas, Marignac and others it has always had its adherents. Since the modern work on Mass Spectra has shown the existence of isotopes and that all elements have atomic weights represented approximately by whole numbers, "Prout's Hypothesis," with modifications, has again assumed a position in chemical thought. Prout discovered hydrochloric acid in the stomach (1803) and alloxan (1818); examined the composition of the urine; the ink of the cuttlefish, and wrote on many diverse topics of bio- and medical chemistry.

The above portrait, by H. W. Phillips, is the property of the Royal College of Physicians by whose kind permission this copy is reproduced.

KARL FRIEDRICH RAMMELSBERG: 1813–1899.

Professor at the University of Berlin with which he was connected for fifty years (1841–1891). His researches greatly enriched inorganic and especially mineralogical chemistry. Showed the isomorphism of sulfur and selenium. In order to help himself in his studies when a young man he opened a laboratory in his mother's attic where he taught two students at a time. "Jeder zahlte für die Stunde vier gute Groschen" (twelve cents) he wrote. In this way he started his researches on the cyanogen compounds. His textbooks were many and renowned and covered chemistry, metallurgy, mineralogy and crystallography.

SIR WILLIAM RAMSAY: 1852–1916.

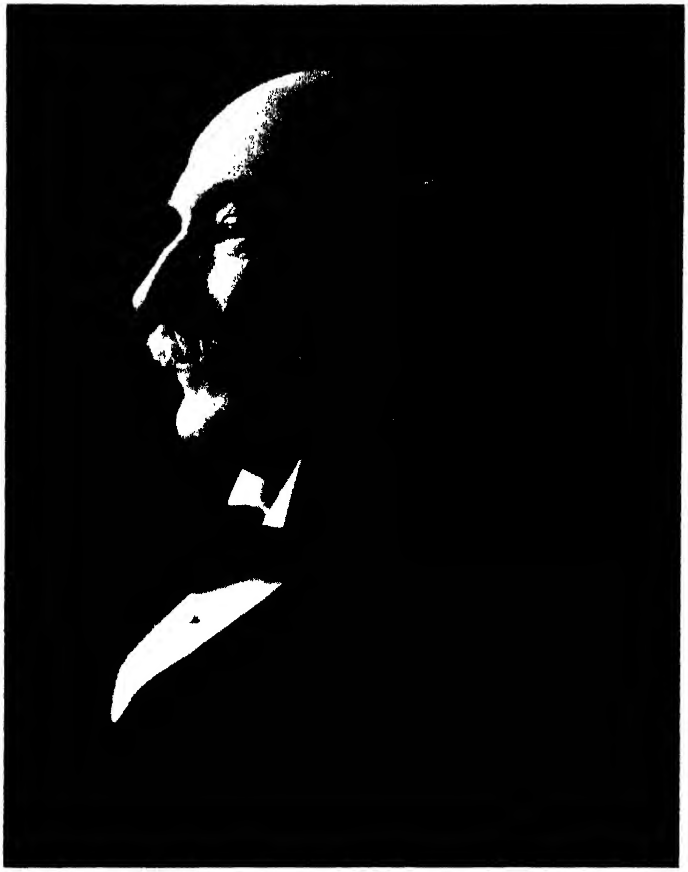
Studied under Bunsen and Fittig; Professor at University College, London. With Rayleigh, and later with Travers, Ramsay discovered the whole group of the rare gases of the air (Argon, 1894; Helium, 1895; Neon, 1898; Krypton, 1898; and Xenon, 1898) which constitute the zero group in the Periodic Table of the elements. These gases are in some instances present in but one part in one hundred and seventy million. In his laboratory was demonstrated the fact that helium is produced by the degradation of the radium emanation. This was the first decomposition of an element to be experimentally demonstrated. He determined the density of this gas, Radon, and showed that it had the highest density of any of the gases and belongs in the same group in the periodic system with the rare gases. Was knighted in 1902; received the Davy Medal and the Nobel Prize (1904).

SIR WILLIAM RAMSAY.

Caricature of Ramsay by "Spy," entitled "Chemistry," appeared as a colored supplement to *Vanity Fair*.

FRANCOIS-MARIE RAOULT: 1830–1901.

Professor at Grenoble. First to show the relation between the freezing and boiling points and vapor pressures of solutions and the molecular weight of the dissolved substance. This relationship is known as Raoult's Law. His work opened a new field for the determination of molecular weights and his discovery that acids, bases and salts produced "abnormal" depressions of the vapor pressures gave great support to the electrolytic theory of Arrhenius. Of humble birth, after a long struggle for an education he became the discoverer of one of the fundamental laws of chemistry. Received the Davy Medal (1892).



THE RT. HON. JOHN WILLIAM STRUTT,
LORD RAYLEIGH: 1842–1919.

Chancellor of Cambridge University and successor of Maxwell as Professor of Physics. Made measurements of sound intensity and found that the sound waves in nitrogen from the air had a different velocity than in nitrogen from chemical sources. In the field of light he studied interference and polarization and from these phenomena explained the blue color of the sky. In his studies on the densities of nitrogen from the air and from ammonia Rayleigh found (1893) that the density of the nitrogen from the air was always the heavier and Ramsay joined him in the search for the cause of the difference. After passing air over red-hot magnesium until all oxygen and nitrogen were removed they found a residual bubble of a new gas with high density, characteristic spectra and complete chemical inactivity. This gas was given the name Argon, and its discovery was jointly announced by Rayleigh and Ramsay, 1894. Rayleigh received the Royal, Rumford, Copley, and Faraday medals and the Nobel Prize (1904) for his researches on the density of gases and for his discovery of argon.

LORD RAYLEIGH.

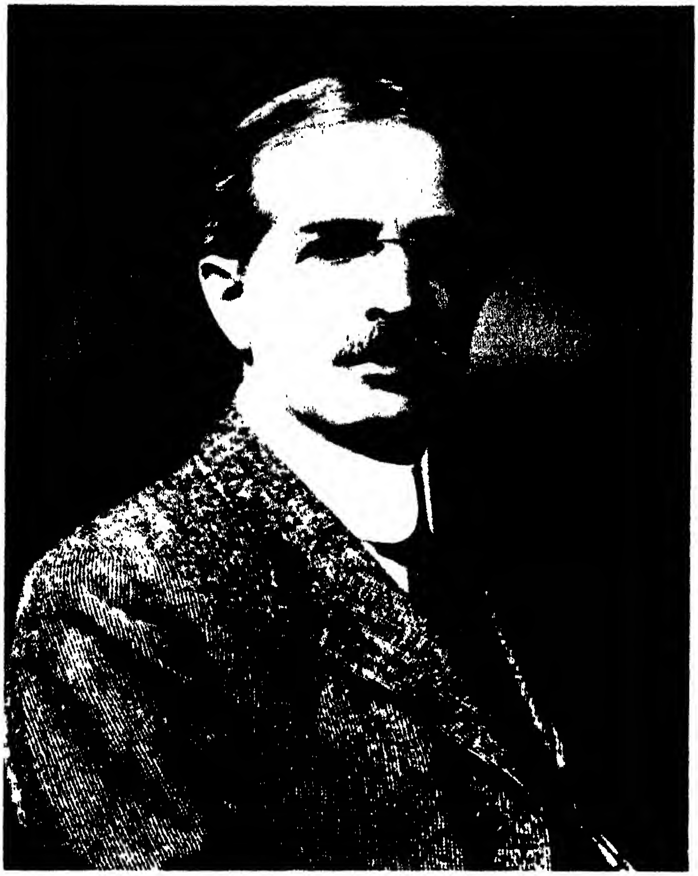
Caricature of Rayleigh by "F. T. D." entitled "Argon" appearing in *Vanity Fair* as a colored supplement, December 21, 1899.

RENÉ ANTOINE FERCHAULT DE RÉAUMUR: 1683–1757.

A French physicist, mathematician and naturalist. He devoted his talents to the development of useful arts and manufactures in France. He so improved the manufacture of iron and steel (1722) that he was given a pension of 12,000 livres, but this he refused to accept and had it applied to experiments for further improving industrial processes. He devised the method for tinning iron substantially as it is done today. Sèrves porcelain was first made through his efforts. He constructed the thermometer known by his name which is in common use in France today.

IRA REMSEN: 1846–1927.

Studied with Liebig and Fittig. Professor of Chemistry (and later President) of Johns Hopkins University. His work was in organic chemistry; discovered saccharine. Wrote eight textbooks which were most successful; founded the *American Chemical Journal*, later absorbed by the *Journal of the American Chemical Society*. His name will be longest remembered as a great teacher who founded graduate research in chemistry in the United States.



THEODORE WILLIAM RICHARDS: 1868–1928.

One of the most distinguished of American chemists; Professor at Harvard University. His determinations of the atomic weights of oxygen, barium, strontium, calcium, zinc, magnesium, iron, cobalt, silver, carbon, nitrogen and lead were everywhere accepted as more accurate than any previously determined. His announcements in 1914 that lead from radioactive minerals has a lower atomic weight than ordinary lead paved the way for an understanding of isotopes, and his studies and speculations on compressibility, on atomic volume and the forces between and within molecules have opened new fields in our knowledge of the constitution of matter. Received the Nobel Prize, 1914, for his accurate determinations of the atomic weight of a large number of chemical elements.

JEREMÍAS BENJAMIN RICHTER: 1762–1807.

Chemist in the Berlin Porcelain Works. The law of proportions by weight was mainly established by his researches (1791) on the combination of acids and bases and the table which he prepared from his results was the first showing chemical equivalents or reciprocal proportions. His work was fundamental but unappreciated for many years. He is responsible for the term "stoichiometry" in our chemical language.

WILHELM KONRAD RÖNTGEN: 1845–1923.

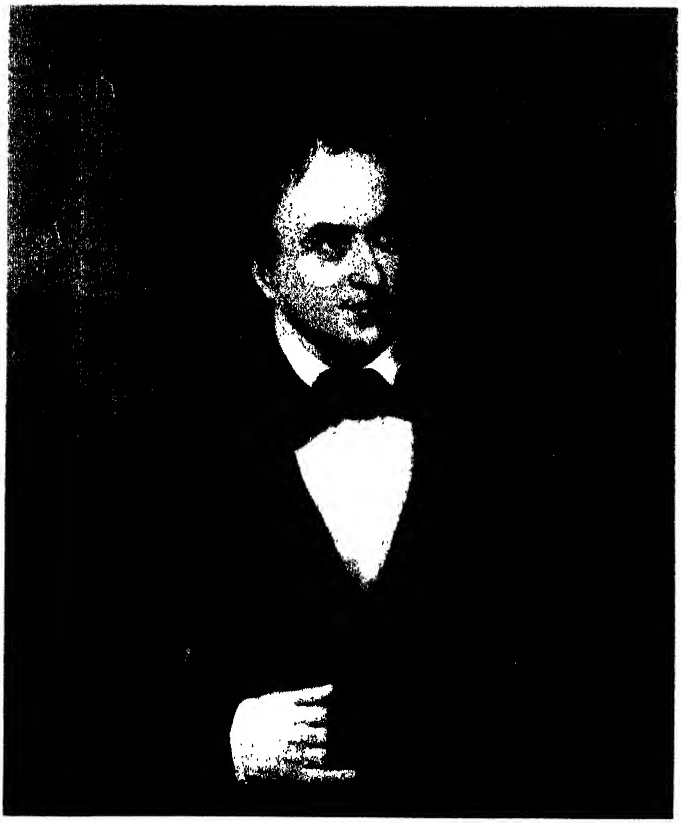
Professor of Physics at Strassburg (1876), Giessen (1879), Würzburg (1885) and Munich (1899). His name is forever associated with the discovery on November 8, 1895, while at Würzburg of the Röntgen or X-rays.

"I was working with a Crookes' tube covered by a shield of black cardboard. A piece of barium platino-cyanide paper lay on the bench and I noticed a peculiar black line across the paper . . . I investigated . . . In a few minutes there was no doubt about it, rays were coming from the tube . . . It was something new, something unrecorded."

Received the Rumford Medal (1896) and the Nobel Prize (1901).

SIR HENRY ENFIELD ROSCOE: 1833–1915.

Studied with Graham, Williamson and Bunsen. Succeeded Frankland as Professor at Manchester (1857). Associated with Bunsen in a long study which laid the foundations of comparative photochemistry; proved that the absorption of the chemical rays in passing through a medium varies directly as the intensity of the light. In 1857 he began a long study of vanadium which resulted in the production of vanadium in a pure state (1869) and its compounds $V_2O_5, V_2O_4, V_2O_3, V_2O_2Cl_6$, $V_2O_2Cl_4, V_2O_2Cl_2$ and showed the relation of vanadium to phosphorus. He also worked on niobium, tungsten, uranium and perchloric acid. He wrote many textbooks on chemistry and with Schorlemmer a "Treatise on Chemistry" which was translated into many languages and which passed through many editions. Knighted in 1884. Received the Royal Medal 1873.



HEINRICH ROSE: 1795–1864.

Professor of Chemistry at Berlin. He showed that columbium and tantalum were distinct elements (1864) and not identical as had been claimed by Wollaston; discovered antimony pentachloride; devised methods of laboratory technique and was the first to make a study of mass action in chemical reactions.

GUILLAUME FRANÇOIS ROUELLE: 1703–1770.

Pharmacist to the Duke of Orleans and Demonstrator at the Jardin du Roi (1774), now the Collège de France. As "Demonstrator" he was forceful and clear and his experiments often showed a disagreement with the theories of the "Lecturer." He was a great figure of his time, his teaching was incomparable and he prepared many who built the foundations of modern chemistry, among whom were Lavoisier, Proust and Nicolas Leblanc. He discovered urea (1737), and hydrogen sulfide, and understood the dehydrating action of sulfuric acid. Fixed the meaning of the term "salt" (1745) and distinguished neutral, acid and basic salts. His views were bold and advanced for his time. In his lectures he became so intense that he would throw off his wig and coat, untie his cravat and collar and even sought his assistant in the anteroom, lecturing as he went. "He loved science for science's sake."

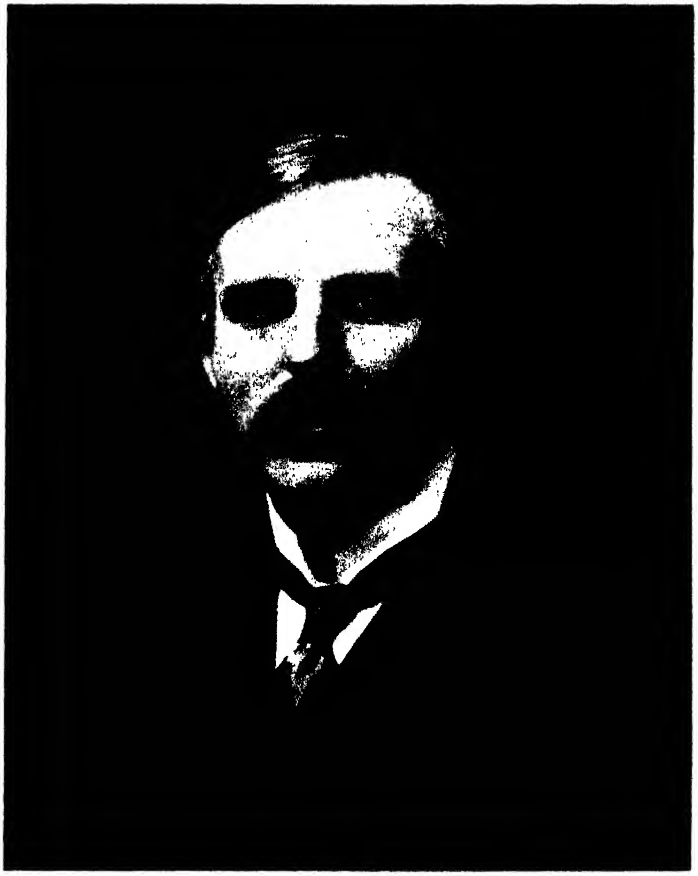
JEAN-FRANCOIS PILÂTRE DE ROZIER: 1756–1785.

Superintendent of the Natural History Collections under Louis XVI. Made the first free balloon flight (November 21, 1783), using a hot-air balloon. Later accompanied by Romain he attempted to cross the English Channel, using a hot-air bag ten feet in diameter placed under a hydrogen-filled bag thirty-seven feet in diameter with the idea that by controlling the fire under the hot-air bag he could control his elevation without loss of hydrogen. After thirty minutes in the air, the balloon burst into flames and both occupants were killed. Rozier was therefore the first to leave the earth in a balloon and the first to be killed in one.

In his lectures on chemistry he was accustomed to fill his lungs with hydrogen and then ignite the gas as he exhaled through a tube as shown in this picture. Once the experiment "backfired"; his comment was "I felt as though I had had my teeth blown out!"

BENJAMIN THOMPSON, Count Rumford: 1753–1814.

One of the most romantic characters in science. Born at North Woburn, Massachusetts, taught school at Rumford (now Concord), New Hampshire, knighted by George III, made count of the Holy Roman Empire by Maximilian I. Experimented on the construction of firearms and the action of gunpowders. Entered the Bavarian service as colonel and became Councillor and Head of the War Department. Lived in princely style in Munich where he carried on his studies and philanthropic works. In supervising the boring of cannon he discovered the relation between heat and work and announced that heat was "not a fluid," as supposed, but "a mode of motion." Studied the conductance of heat through liquids, the expansion of water and of ice and showed the influence which these properties exert on the climate. On returning to England he improved the construction of fireplaces and stoves and studied the proper preparation of food and thus early laid the foundations of home economics and dietetics. Founded the Royal Institution (1800). Married Lavoisier's widow (1805). Buried at Auteuil near Paris. Left bequests to Harvard University, the American Academy of Arts and Sciences, and the Royal Society of London. His birthplace, thirteen miles north of Boston, is preserved as a memorial.



SIR ERNEST RUTHERFORD, Lord Rutherford: 1871–1937.

Born in New Zealand; prominent pupil of J. J. Thomson; Professor at McGill (1898) and Cambridge (1919). Leader in the new conception of atomic structure. Discovered thorium emanation (1900); announced, with Soddy, a new theory of atomic disintegration and the nuclear nature of the atom (1902). Showed that radium emanation was helium (1909) and later succeeded in counting the number of helium atoms thrown off by radium and measured the amount of helium produced — 39 cu. mm. per year per gram of radium. Expelled positively charged hydrogen atoms from the nucleus of nitrogen, sodium, aluminum and phosphorus by bombardment with alpha particles and showed that an atom of aluminum consists of 6 He + H_3. Gave the name of "proton" to the hydrogen nucleus. Received many medals and honors and the Nobel Prize for his investigations into the disintegration of the elements. Knighted in 1914 and raised to the Peerage in 1931.

PAUL SABATIER: 1854–1941.

Assistant to Berthelot at the Collège de France. Professor at Toulouse (1882). His great work was in the field of catalysis. Studied the catalytic behavior of various oxides as oxidizing catalysts and as dehydrogenating and dehydrating agents. Developed the theory of the formation of a temporary unstable combination of catalysts in general. In his work he studied the action of finely divided metals, as iron, copper, cobalt and nickel, as hydrogenating agents and changed carbon monoxide to methane and unsaturated to saturated compounds, notably the addition of hydrogen to the unsaturated oils, and thereby laid the foundation for large industrial applications. Shared the Nobel Prize with Grignard for 1912. Received the Davy Medal, 1915.

CARL WILHELM SCHEELE: 1742-1786.
Statue by Börjeson in Stockholm.

Swedish apothecary. He will remain for all time one of the most distinguished experimental chemists. Among the many elements and compounds discovered or identified by him are chlorine, oxygen, barium oxide (1774), hydrogen fluoride (1777), the manganates and permanganates as compounds of a new element (1774), Scheele's Green ($CuHAsO_3$), arsine, hydrogen cyanide (1782). He was unaware of the poisonous properties of the latter compound, however. He recognized the different stages of oxidation of iron, copper, and mercury. In the organic field he discovered tartaric acid (1769), aldehyde (1774), oxalic and uric acids (1776), glycerine (1779), lactic acid (1780) and pyrogallol (1786). This formidable list does not include all of the contributions of this remarkable man who died at the early age of forty-four. His discovery of oxygen which he named "Feuerluft" was not published until after his death when his notebooks were edited. "It is truth alone that we desire to know and what a joy there is in discovering it," he wrote, and in so doing characterized himself.

CARL WILHELM SCHEELE.

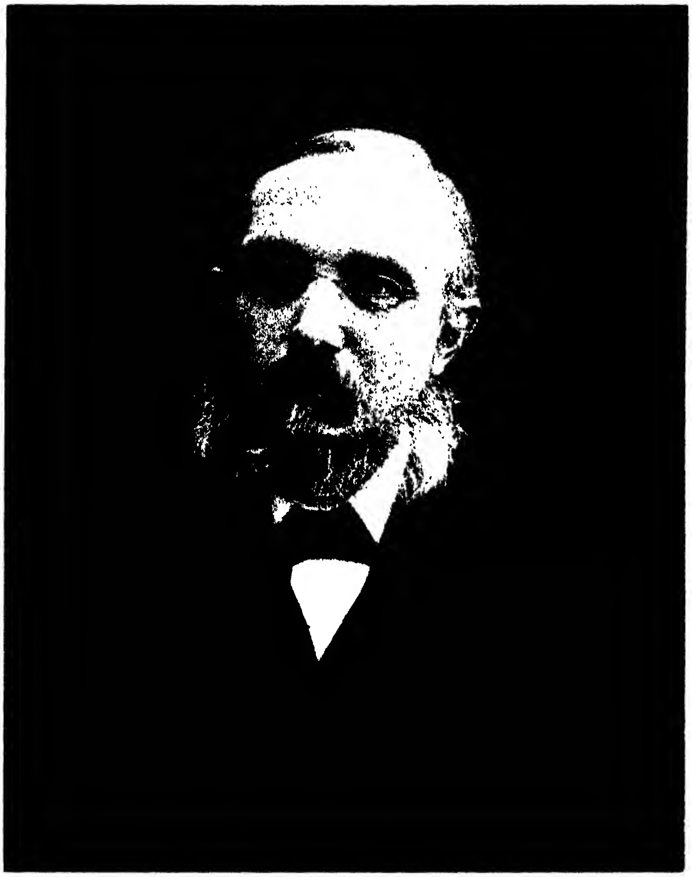
For years there was no known authentic likeness of Scheele. Three years after his death the Academy of Sciences had a medal struck in his honor carrying a profile only. In 1929 there was found in Vienna in a private autograph collection a photograph recorded as Scheele and as having been made from an ivory miniature in the possession of a Frl. Brüggemann, a collateral descendant of Scheele. On the report of the existence of such a miniature the Swedish Society of Pharmacists immediately started a search for this miniature. An expert was engaged, who for two years searched all possible clues throughout Europe before what is believed to be the miniature, shown above, was finally located in the possession of a distant descendant of Scheele. The painting shows Scheele at about the age of twenty-five before he became famous. It is now in possession of the Swedish Society. Scheele was buried in the churchyard in the village of Köping but in the course of time the exact location of his grave was lost. Some eighty years after his death workmen accidentally came across the silver coffin-plate which is now in the possession of the Swedish Society of Pharmacists, and a small monument now marks the burial spot.

CARL WILHELM SCHEELE.

Statue by Carl Milles erected in Scheele Park, Köping.

CHRISTIAN FRIEDRICH SCHÖNBEIN: 1799–1868.

A German chemist and long a professor at Basel (1852). Best known for his discovery of ozone (1840) and his researches on guncotton (1846), and the passivity of metals. Schönbein was disinclined to accept the atomic theory or exact quantitative analysis and this attitude of mind made many of his contemporaries regard his attainments with suspicion. Ostwald has said of him that "of all modern chemists Schönbein most retained the mental attitude of an alchemist."



CARL SCHORLEMMER: 1834–1893.

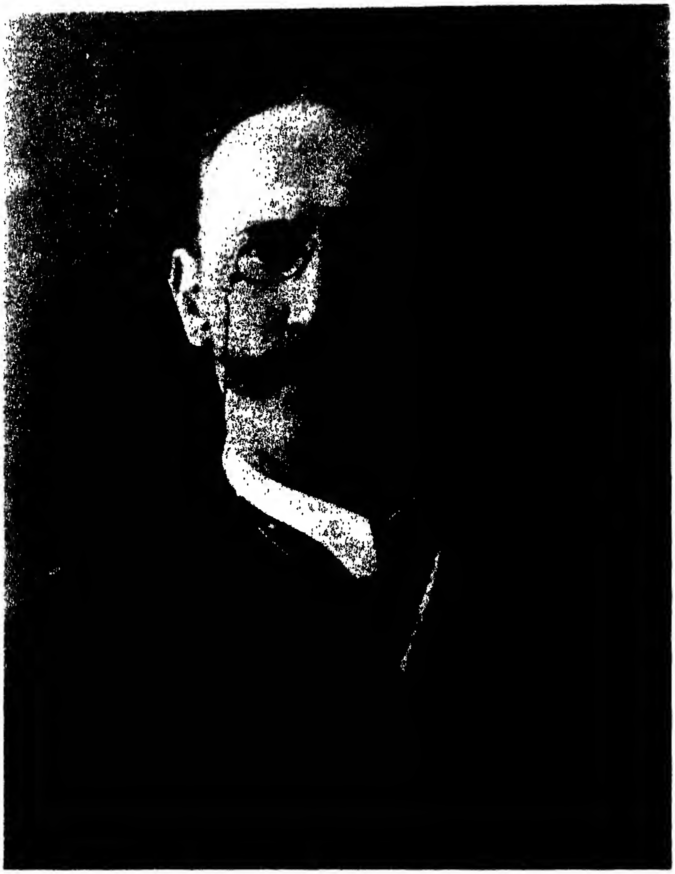
Pupil of Bunsen and Kopp. Born a German he spent his productive life in England as professor at Owens College (1874). He investigated the homologues of the aliphatic series and showed the relation of the hydrocarbons in a series to their substitution products. Discovered (1866) a general method for converting a secondary into a primary alcohol. With Sir Henry Roscoe he co-operated in writing their famous "Systematic Treatise on Chemistry" (1877) which was a standard work for many years. His "Rise and Development of Organic Chemistry" (1879) was highly successful.

CARL LUDWIG SCHOTTEN: 1853–1910.

Professor in the Physiological Institute, Berlin. Investigated piperidine and contributed much towards elucidating its constitution. Developed the method by which the benzoyl group may be introduced into a compound, known as the "Schotten reaction." Investigated ichthyol, studied the source of hippuric acid in urine and the composition of the acids of the bile.

PAUL SCHÜTZENBERGER: 1829–1897.

Successor of Balard at the Collège de France. Isolated xanthopurpurine, purpurine, and pseudopurpurine and carminic acid. Discovered the carbonyl compounds of platinum and the platino-stannic radical, Pt_2Sn_3, and the silicocarbon, Si_2C_2. Discovered hyposulfurous acid. His studies undermined the dualistic theory and his work on the proteins, which he pursued for fifteen years, gave the first clear impression of their constitution. His preparation of the cyanhydrines of glucose and levulose and their subsequent hydrolysis to acids gave a method for the proof of the constitution of the sugars — later employed with success by Fischer.

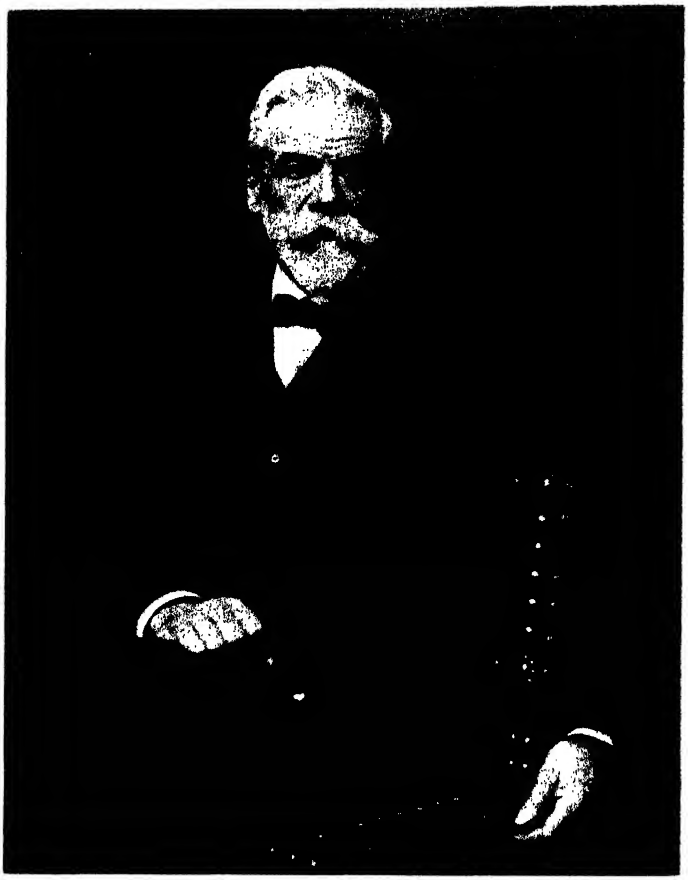


RICHARD SEIFERT: 1861–1919.

An industrial chemist who applied chemical studies to the development of a great business. As a student he discovered the reaction for the production of salicylic acid which became a world product. Introduced derivatives of salicylic acid for rheumatism and neuralgia and antiseptics for bladder and intestinal troubles. Developed the commercial production of saccharine and many therapeutics and antiseptics of the benzene type.

ZDENKO HANS SKRAUP: 1850–1910.

Professor at Graz (1886) and Vienna (1906). Synthesized quinoline ("Skraup's synthesis") and established the structure of its molecule. Studied the composition of quinine and cinchonine; discovered the easily crystallized acetyl derivatives of cellulose and the formation of cellobioses; determined the molecular weights of starch and cellulose from the chlorine content in the chlor-acetyl derivatives of these carbohydrates. He also made investigations on the proteins, on cocaine, on morphine and the transformation of maleic and fumaric acids.



ERNEST SOLVAY: 1838–1922.

Founder of the Ammonia-Soda Industry. At the age of twenty-one, while a helper in a gas factory of Brussels, he developed the process which revolutionized the soda industry and displaced the LeBlanc process. The firm of Solvay and Company was founded in Brussels in 1863. The first soda produced in the United States by this process was in 1884. Solvay became rich and influential, but always remained sympathetic towards all movements for bettering the conditions of the poor. Founded the Institute Solvay in Brussels for this purpose.

GEORG ERNST STAHL: 1660–1734.

Professor of Medicine at Halle and later Prussian Court Physician. Propounder of the famous Phlogiston Theory — the first general explanation of chemical transformations. His theory exercised widespread influence and was accepted until the time of Lavoisier. He was of a melancholy and solitary nature but one of the ablest chemists of his time. Believed relative affinities could be determined by the order in which substances expel one another from compounds. In his youth he accepted alchemy, later he warned against its frauds.

JEAN-SERVAIS STAS: 1813–1891.

Professor at Brussels for thirty years. His scientific life was largely spent in testing the validity of Prout's Hypothesis. The painstaking and exact methods which he developed in his determination of the atomic weights of silver, lead, sulphur, carbon, hydrogen, the halogens, and the alkali metals had never been approached before and put Stas's work in a class by itself. His results disproved the claim of Prout. "A faithful votary of science whose chief aim was truth." Received the Davy Medal in 1895 and a special medal from the Belgium Royal Academy in 1891.

LOUIS JACQUES THENARD: 1777–1857.

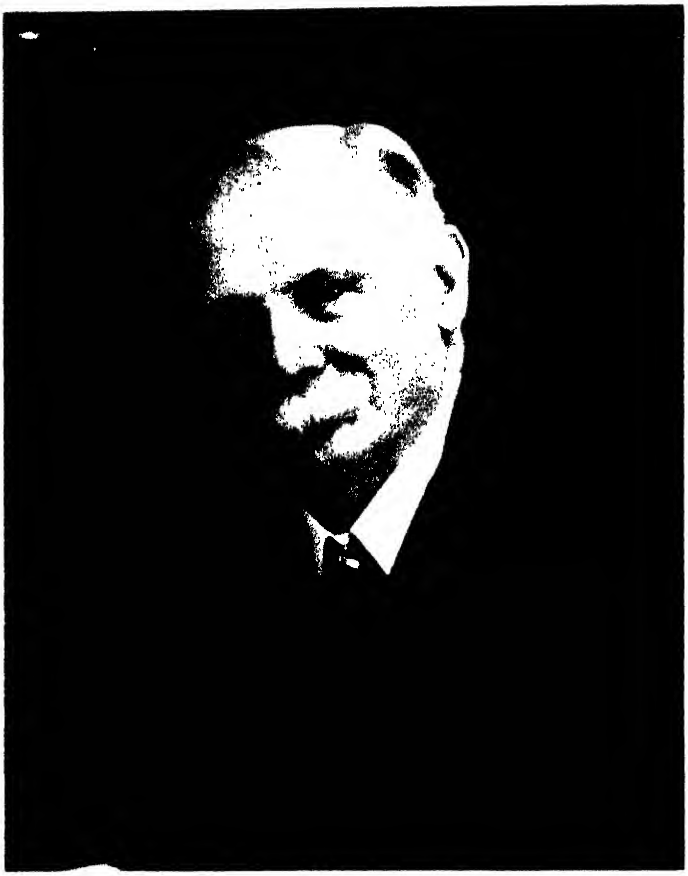
Born a peasant, he became a baron and a peer of France. Studied pharmacy and was a pupil of Berthollet, Fourcroy, and Vauquelin; professor at the Collège de France. Disputed Berthollet's views on the composition of metallic oxides; worked with Gay-Lussac on the reduction of the oxides of the alkali metals with iron; the amides of the alkali metals, and obtained boron by the reduction of boric oxide with potassium. He discovered hydrogen peroxide (1818) and devised Thenard's blue as a pigment for porcelain. He was a famous teacher and his "Traité de Chimie Elémentaire" was a standard work for many years. He did important work also in organic chemistry.

JULIUS THOMSEN: 1826–1909.

Professor at Copenhagen where for fifty years he carried on his investigations in thermochemistry. Developed the principle that the heat of formation is a measure of chemical affinity. From thermochemical data he calculated the avidity of acids and alkalies and the distribution of a base between two acids. This work contributed largely to the Law of Mass Action. Received the Davy Medal (1883). His four-volume "Thermochemische Untersuchungen" is one of the classics of thermochemistry.

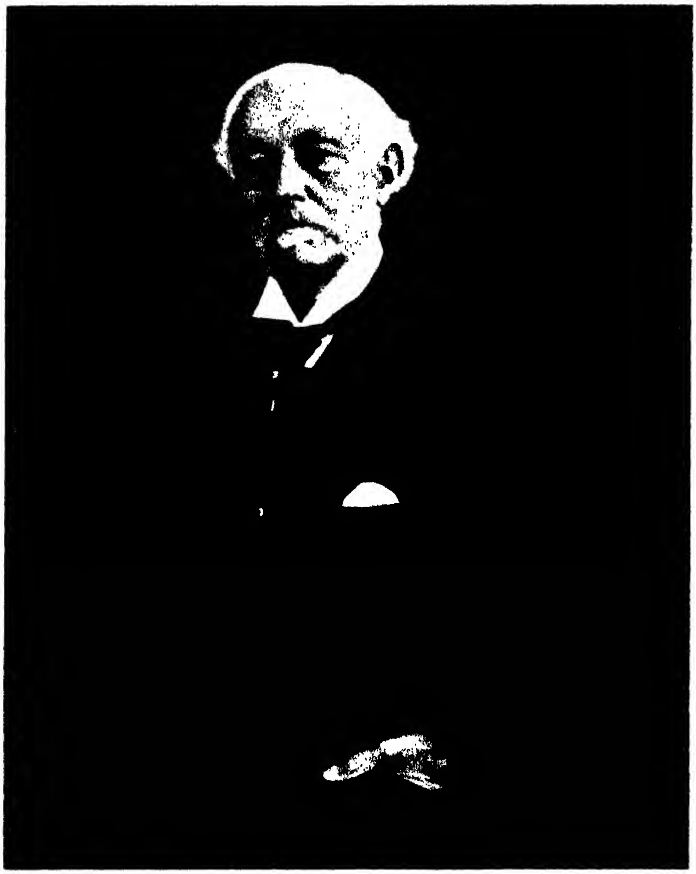
SIR JOSEPH JOHN THOMSON: 1856–1940

Professor of Physics at the University of Cambridge. His researches on the discharge of electricity through gases revealed the inner nature of the atom and laid the foundation for our present conception of the corpuscular theory of matter. Announced that cathode rays are particles of negative electricity; determined the ratio of the electric charge of the electron to its mass, e/m, and developed the concept of the unity of matter and energy. Received the Royal, Hughes, Hodgkins and Copley medals and the Nobel Prize (1906).



SIR EDWARD THORPE: 1845–1925.

Studied with Roscoe and Bunsen. Professor at the Royal College of Science (1885). His work was in the field of inorganic chemistry, particularly the compounds of phosphorus and fluorine, POF_3, and PSF_3. He determined the atomic weights of silicon and gold and studied the change in the vapor density of hydrogen fluoride with changes of temperature and the relation between boiling-points and critical temperatures. Traced the source of wholesale arsenical poisonings in England to the presence of arsenic in a shipload of pyrites which was used in the manufacture of sulfuric acid which in turn had been used in the manufacture of glucose used in the making of beer! Published textbooks in Inorganic Chemistry, Qualitative and Quantitative Analysis, and wrote extensively on the History of Chemistry. Edited the "Dictionary of Applied Chemistry." Received the Royal Medal (1889).

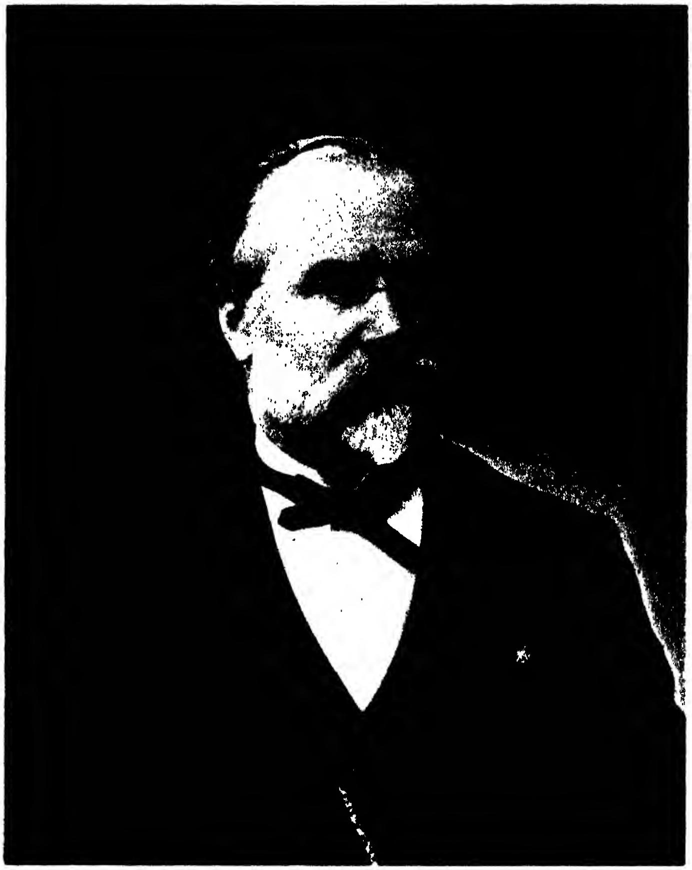


SIR WILLIAM AUGUSTUS TILDEN: 1842–1926.

Professor at the Royal College of Science (1894). Studied the periodides of caffein, strychnine and brucine; determined the composition of NOCl. His work on the decomposition of terpenes by heat was the beginning of the modern petroleum-cracking. He polymerized isoprene and was the first to synthesize rubber (1892). Author of "Famous Chemists. The Men and Their Work."

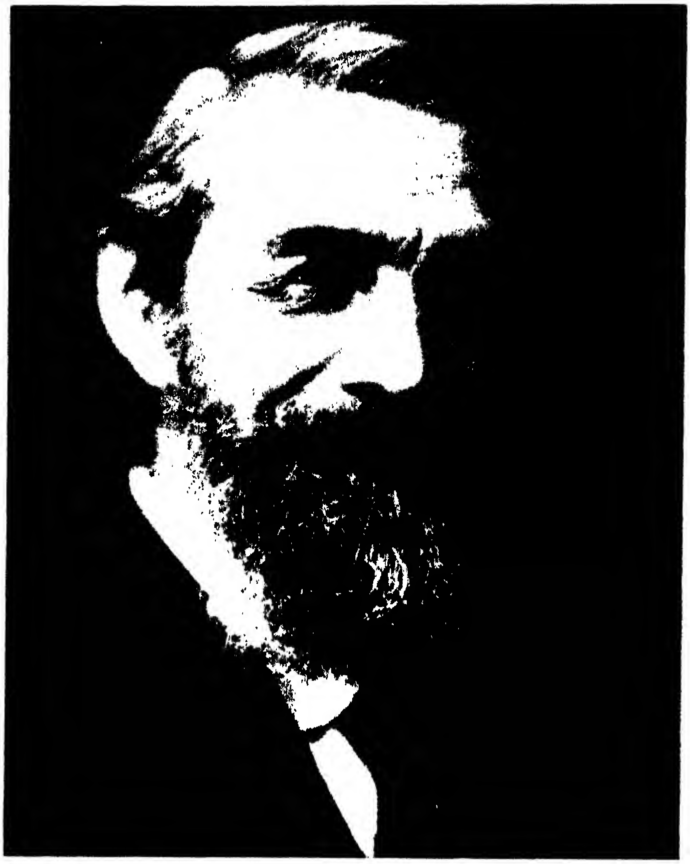
BERNHARD TOLLENS: 1841–1918.

Student of Wöhler and Professor at Göttingen. His investigations lay mostly in the field of the carbohydrates. He studied the hydrolysis of starch by sulfuric acid; the polarization of sugar and the relation of sugars to formaldehyde; determined the molecular weights of raffinose, arabinose and xylose. Developed the very sensitive "Tollens" test for aldehyde and an aldehyde lamp used in sanitary work.



LOUIS J. TROOST: 1825–1911.

Professor at the Sorbonne (1874–1900). Produced zirconium by reducing its halides with iron, aluminum or sodium, and studied the properties of zirconium and lithium. Worked with high temperatures in the synthesis of minerals and the dissociation of compounds. Much of his work was done jointly with Deville. Investigated porosity of metals at high temperatures, solubility of gases in metals, effect of manganese and silicon on properties of commercial irons. The solid solution of carbon in iron has been named "troostite."



GEORGES URBAIN: 1872–1938.

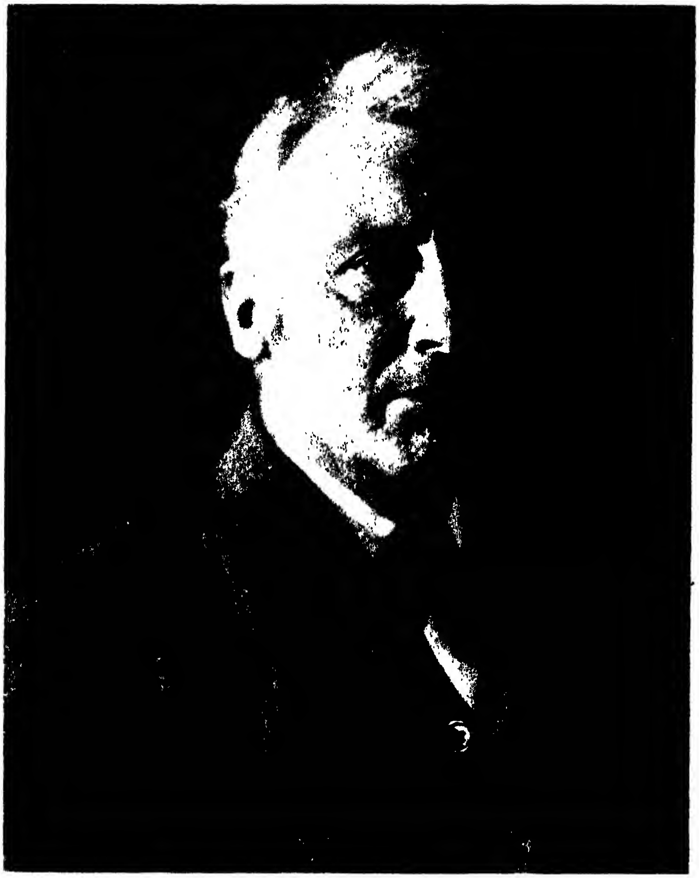
Studied under Friedel, Schutzenberger and Perrin. Professor at the Sorbonne (1908) and Director of the Institute of Physico-Chemical Biology (1928). His field of investigations was largely with the rare earths. He showed that this confusing group consisted of fifteen members and he determined the atomic weights of many of them. By many thousand fractional crystallizations of ytterbium nitrate in nitric acid he obtained the oxides neoytterbia and lutecia. The element lutecium is No. 71 in Moseley's table and Urbain is credited with its discovery. The element No. 72 (celtium) predicted by him was later obtained by Hevesy and named hafnium.

JOHANNES DIDERIK VAN DER WAALS: 1837–1923.

Professor of Theoretical Physics, Amsterdam (1877). A self-made man who became a great figure in modern physics and physical chemistry. Constructed a modified form of the gas equation which expresses the deviation from Boyle's and Gay-Lussac's laws (1881). His studies embraced the electrolytic dissociation formula (1891), surface tension (1894), theory of mixtures (1894), and the continuity of gaseous and liquid states (1899). The practices employed in the modern liquefaction of gases have been developed from van der Waals' theories. Dewar, who first liquefied hydrogen, wrote to Onnes, who first liquefied helium, "he was the master of us all whom we cannot honor too much." Received the Nobel Prize (1910) "for his equation of state for gases and liquids."

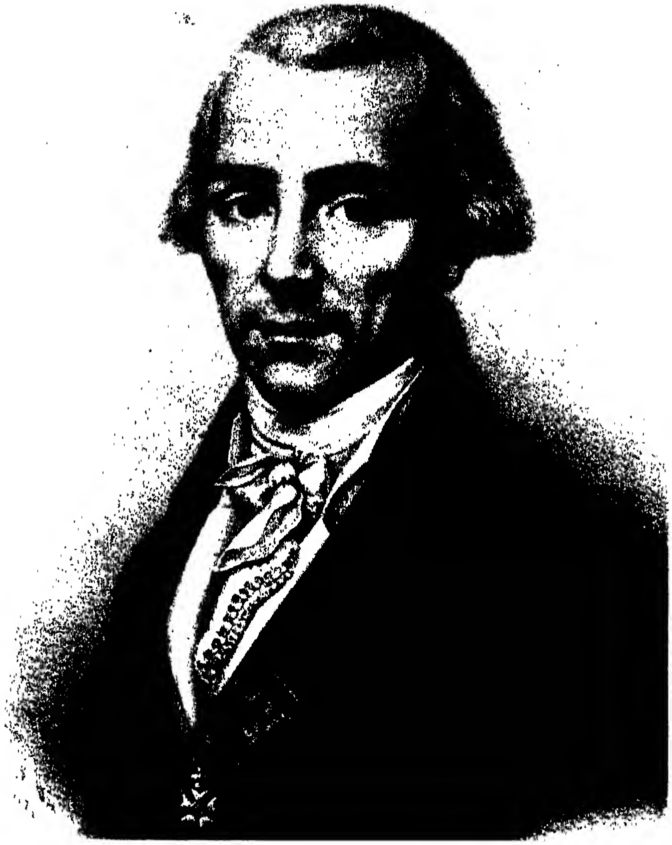
JOHANN BAPTIST VAN HELMONT: 1577–1644.

Belgian physician. An original investigator of the first rank but imbued with alchemical ideas. Vigorous supporter of the theory of the transmutation of the base metals into gold. Grew a willow tree in a weighed amount of earth for five years and since the weight of the earth remained unchanged he regarded water as the primal substance from which the tree was formed. Discovered that a gas was formed when wood was burned and that the gas was the same as produced by fermentation and by the action of acids on marble. Used the term "Gas" in place of the previously used term "Air." Introduced chemical ideas into medicine. Opposed the idea that fire was a material.



JACOBUS HENRICUS VAN'T HOFF: 1852–1911.

Professor at Amsterdam (1877) and Berlin (1896). As a student he published an article (1874) which developed into the book "La Chemie dans l'Espace" and became the foundation of the present views of stereochemistry. He made the discovery that all optically active carbon compounds contain an asymmetric carbon atom. This was later extended to include nitrogen compounds and compounds of carbon with double linkage of the "*cis*" and "*trans*" configuration. Le Bel shares with van't Hoff credit for an independent discovery of the cause of optical activity. With Ostwald van't Hoff founded the *Zeitschrift für physikalische Chemie*. His studies included the law of mass action, dilute solutions, osmotic pressures, and the formation of double salts of the Stassfurt deposits. Received the Nobel Prize, 1901, and hence was the first recipient of this signal honor for chemical achievement.

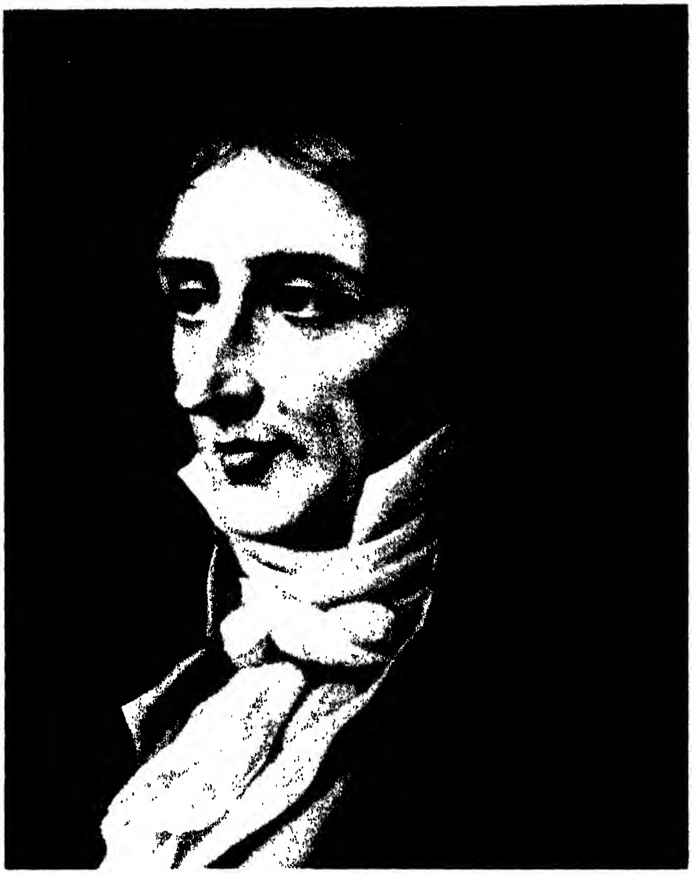


LOUIS NICOLAS VAUQUELIN: 1763–1829.

Pupil and associate of Fourcroy; professor at the School of Mines and successor of Fourcroy on the Medical Faculty of Paris. He was a strong supporter of Lavoisier's new antiphlogiston theory. Discovered chromium and beryllium oxide in 1797, and developed methods of separation for metals of the platinum group. His discovery of chromium followed the solution of an ore which gave a yellow precipitate with a lead solution. This was a new reaction and he concluded that a new element was present which he isolated by reduction of the oxide with carbon. Fourcroy suggested the name because of its colored salts. Vauquelin's contributions extended over the range of inorganic and organic chemistry.

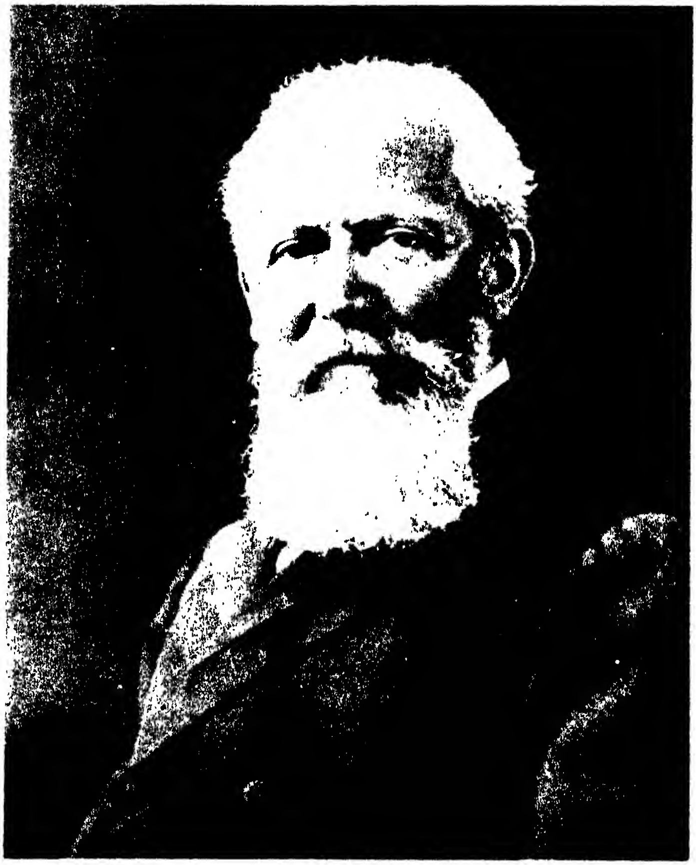
JACOB VOLHARD: 1834–1910.

Professor at Munich (1869), Erlangen (1878) and Halle (1882). Brilliant and favorite pupil of Liebig at Giessen. There then followed a period of indolence and he was sent to London to be with Hofmann, a friend of the family. Of a fiery nature he threw his preparations into the sink when his analyses did not agree and left the laboratory vowing never to return. Hofmann saved him from this act. In the small overcrowded laboratory of Kolbe in Marburg Volhard found himself and for the rest of his life was a tireless worker. Synthesized sarcosine (1862) and creatine (1869), worked on guanidine and cyanamide. Developed the thiocyanate titration method for silver (1874), synthesized thiophene from succinic acid (1885) and developed iodimetry. His "History of the Metals" (1897), "Life of Hofmann" (1902) and "Life of Liebig," two volumes (1909), are renowned.



ALESSANDRO VOLTA: 1745–1827.

Italian physicist; professor at Pavia (1779). Famous for his construction of the first electric battery or voltaic cell. Volta described his "pile" on March 20, 1800, in a paper to the Royal Society of London. His discovery led to the electrolysis of water by Nicholson and Carlisle (1800) and to the electrolysis of acids, bases and salts and to Davy's isolation of sodium and potassium (1807). Davy said "the voltaic battery was an alarm bell to experimenters all over Europe." Volta also produced the electroscope and the electrometer. Received the Copley Medal (1791). Napoleon had a medal struck in his honor and created him a Count of Italy. The volt, the unit of electromotive force, is named in his honor.



OTTO WALLACH: 1847–1931.

Studied under Wöhler and Hofmann. Professor at Bonn (1876) and Göttingen (1889). His researches were in the field of organic chemistry in which he laid the groundwork for aromatic chemicals, both perfumes and spices. His investigations began in 1884 and continued through a long period of years, and were collected in a book "Terpenes and Camphor" in 1909. He also investigated the azo and diazo compounds and synthesized optically active compounds which did not contain an asymmetric carbon atom. His work on the terpenes opened a field in the chemical industry of the ethereal oils. Received the Nobel Prize in 1910 for his pioneer work in the alicylic compounds.

KARL AUER von WELSBACH: 1858–1929.

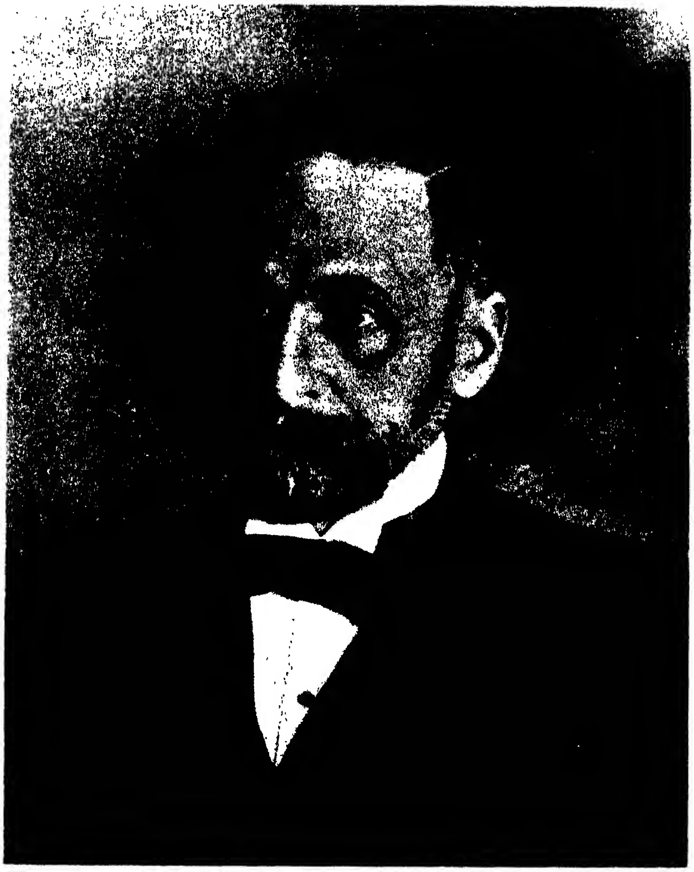
A native of Vienna; pupil of Bunsen. Separated didymium into neodymium and praseodymium (1885) and decomposed ytterbium (1906). In 1897 he invented the osmium lamp and in 1903 the pyrophoric ferrocerium alloy now in widespread use in gas and pocket cigarette lighters. His greatest contribution to science was that of the incandescent gas mantle (1885) known as the Welsbach mantle.

ALFRED WERNER: 1866–1919.

Professor at Zurich. As a student under Hantzsch he became interested in the stereochemistry of nitrogen compounds, and the isomeric forms of the oximes. He is best known for his work on the complex compounds of cobalt, chromium and platinum. His theories of primary and secondary valence and the "coordination number" were new and revolutionary. In 1911 he succeeded in separating the chlor-diethylene ammines of cobalt into their optically active components and thus introduced stereo-isomerism into inorganic chemistry. He developed a new field in inorganic chemistry and his researches illuminated the chemical world for twenty-five years. Received the Nobel Prize in 1913 for his work on the linkage of atoms in molecules.

ALEXANDER WILLIAM WILLIAMSON: 1824–1904.

Professor at University College, London (1849), where he succeeded Graham. As a child he lost the sight of one eye and the use of one arm and Gmelin in Heidelberg advised against his pursuit of chemistry with such a handicap, but undaunted Williamson turned to Liebig in Giessen. Studied the decomposition of oxides by chlorine and the blue compounds of iron and cyanogen. His greatest contribution lay in the theory of ether formation wherein he showed the replacement of hydrogen in alcohol by the group C_2H_5 in the production of ether. His work on this point demonstrated the di-valence of oxygen. In 1851 he announced his theory of the "water type" based on the relations H.OH, C_2H_5.OH, C_2H_5.O.C_2H_5. This theory is one of the milestones of organic chemistry. He introduced a systematic nomenclature in chemistry still in use. Received the Royal Medal (1862).

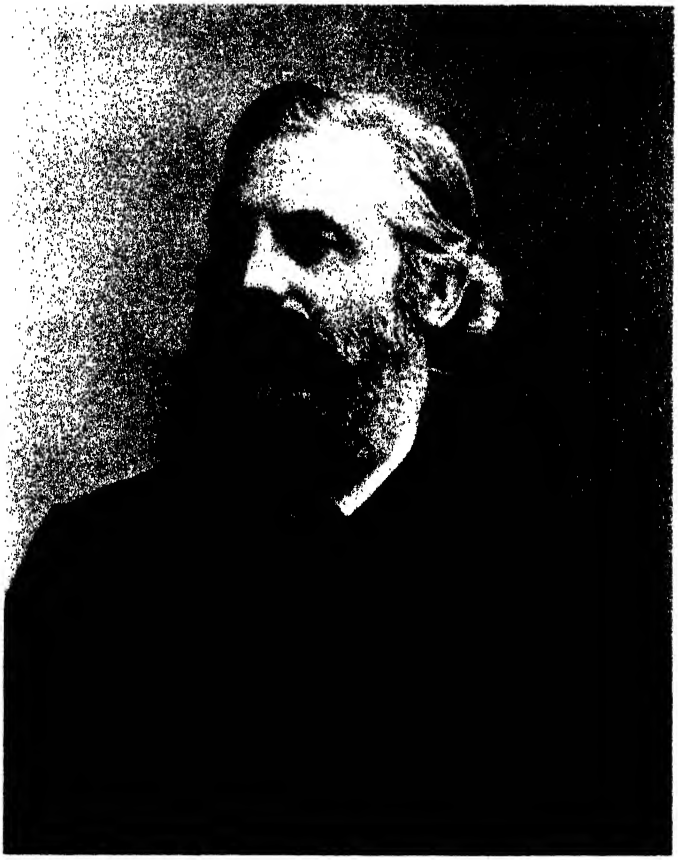


RICHARD WILLSTÄTTER: 1872–1942.

Director of the Kaiser Wilhelm Institute (1912) and Professor at Munich (1916). Worked on the structure and synthesis of the alkaloids tropine, atropine, and cocaine (1903). In 1907 he turned his talents to the investigation of chlorophyll and the assimilation of carbon dioxide by plants; demonstrated the existence of two chlorophylls; studied the flower pigments and showed their relation to chlorophyll and the close relation of the blue of the cornflower to the red of the rose. Investigated the enzymes of plant and animal origin. His work with cocaine led to the commercial production of local anesthetics and with the carotinoids into the field of vitamins. Received the Davy Medal (1932), the Gibbs Medal (1933) and the Nobel Prize (1915) for his researches into the coloring matter of plants, especially chlorophyll. The antisemitic conditions in Munich forced his retirement in 1925 and he left Germany to die in exile in Switzerland.

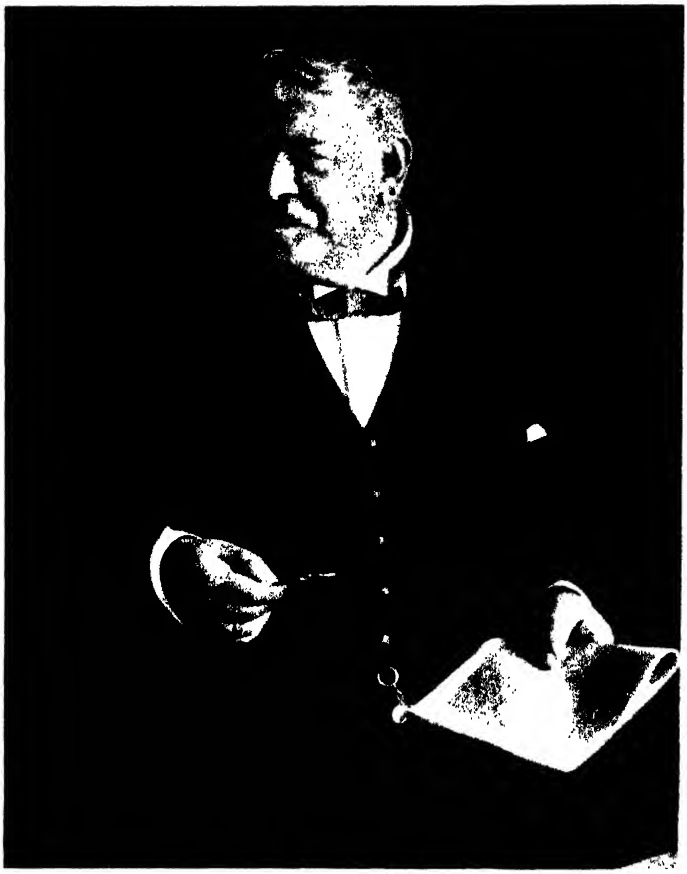
CLEMENS WINKLER: 1838–1904.

Professor at Freiberg, Saxony (1873). The outstanding inorganic chemist of his time. Manager of a cobalt-glass works (1860–1873). Prepared metallic cobalt in quantity. Determined the atomic weight of indium. Early worker in electrochemical analysis and devised the perforated rotating cathode and a separation of nickel, zinc and bismuth. Introduced the term "normal weight" in volumetric analysis and the test for carbon monoxide by palladium chloride; determined sodium hydroxide in the presence of alkali carbonates. An analysis of the newly discovered mineral Argyrodite gave results seven per cent too low. After working day and night for several months he discovered on February 6, 1886, the presence of a new element which he named Germanium. This discovery fulfilled the prediction of ekasilicon by Mendeléeff (1871). Reduced oxides with magnesium, and prepared hydrides of metals. Developed the Contact Process for sulfuric acid (1878). Improved gas analysis and invented the three-way stopcock.



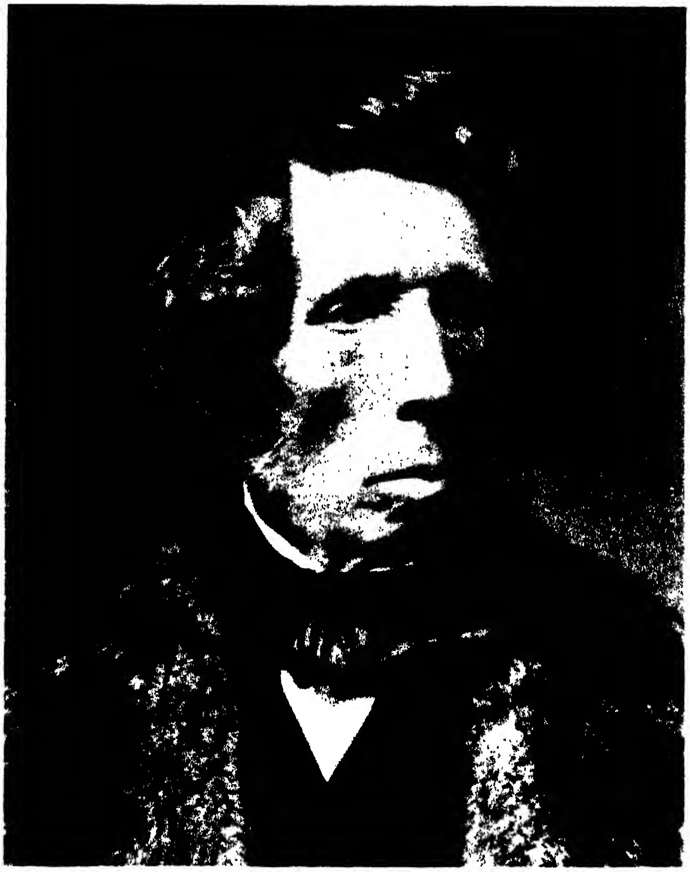
JOHANNES WISLICENUS: 1835–1902.

Professor at Zurich, Würzburg (1872) and Leipzig (1885). His work was in the field of organic chemistry and especially in stereochemistry. From his study of the lactic acids he recognized that ordinary formulae were insufficient to account for the differences in their properties; in 1869 he suggested that space relations must be considered and proposed the name "geometric isomerism." Worked on aceto-aceticester and its rôle as a synthetic agent; esterification of ketons, activity of alkyl halides, and ring formations. Devised the name "alkyl." One of the commanding personalities in the chemical world of this fruitful period. Received the Davy Medal in 1898.



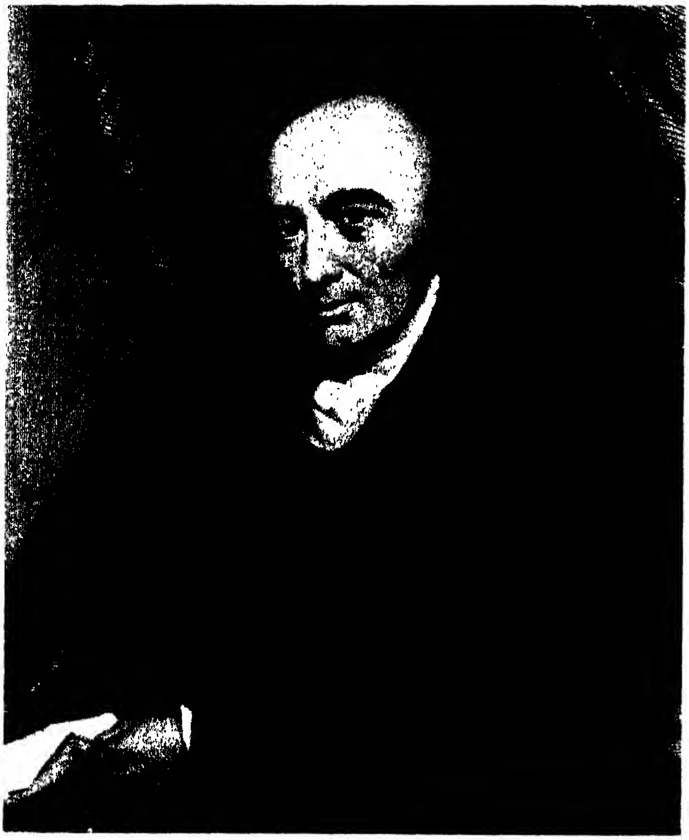
OTTO NIKOLAUS WITT: 1853–1915.

Professor at the Technische Hochschule, Charlottenburg (1891). Engaged in industrial chemistry in England (1875) in the newly expanding coal-tar dye production. Discovered the dyes chrysoidine and tropaeoline and later many others while associated with the various chemical works. His scientific papers were mostly on dyes and dyeing wherein he introduced the theory of chromophores and chromogens. Founded and for many years was editor of *Prometheus* and of *Die chemische Industrie.*



FRIEDRICH WÖHLER: 1800–1882.

A student of Gmelin and Berzelius and professor at Göttingen (1836). His discovery of the transformation of ammonium cyanate (NH_4OCN) to urea ($(NH_2)_2CO$) in 1828 demolished the theory of a vital force as necessary for the formation of organic compounds and no longer made possible a strict separation of organic and inorganic chemistry. This transformation also introduced the conception of intra-molecular arrangement of the atoms. Wöhler isolated aluminum (1827), beryllium (1828) and an impure titanium. With Liebig he discovered the benzoyl radical (1832), amygdalin (1837), hydroquinone (1848), calcium carbide (1862) and showed the analogy between carbon and silicon (1863). The strong friendship that existed between the gentle and mild-mannered Wöhler and the imperious and quick-tempered Liebig developed over the composition of silver cyanate and fulminate — a case of isomerism.

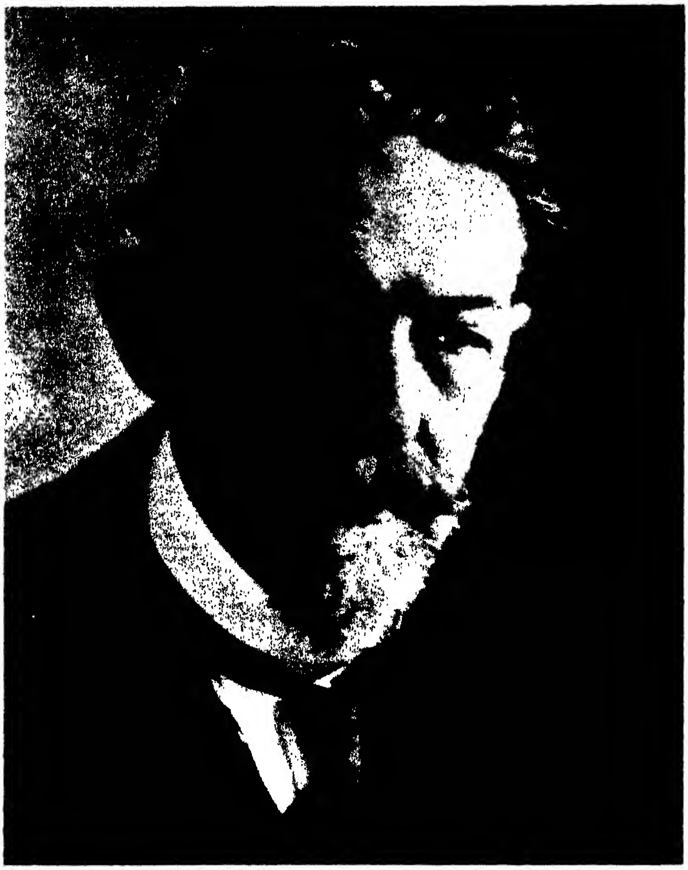


WILLIAM HYDE WOLLASTON: 1766–1828.

One of the ablest of British chemists and physicists. He devised a method for working platinum, invented the reflecting goniometer, and discovered palladium (1804) and rhodium (1805). His use of "equivalents," based on oxygen as ten, aided the advance of electrochemistry and was of great practical use at a time when the notions of atomic and molecular weight had not been clarified. He was a strong supporter of Dalton's atomic theory from the first and did much to aid in its recognition.

CHARLES ADOLPHE WURTZ: 1817–1884.

Pupil of Balard, Dumas and Liebig. Professor at the Sorbonne (1875). An outstanding French chemist at a period when chemistry was undergoing rapid expansion. Studied the acids of phosphorus; determined the constitution of hypophosphorous acid; discovered phosphorous oxychloride (1847), the primary aliphatic amines (1848) and the synthesis of hydrocarbons by the action of sodium on alkylhalides (1855). Established the constitution of glycerine; prepared and studied glycol and many of its derivatives, including lactic acid from propylene glycol. Studied the condensation of aldehyde and discovered aldol (1872). Wrote many books on chemistry, probably the most outstanding being the "Dictionnaire de Chemie pure et appliquée." Editor of the *Annales de Chemie et de Physique* for many years.



RICHARD ZSIGMONDY: 1865–1929.

Professor at Göttingen (1907). As chemist in a large glass concern he first became interested in the part played by gold in the color of ruby-glass. This led to his discovery of water suspensions — sols — of gold, wherein the color is due to particles of gold of submicroscopic size held in suspension by electric charges on the particles (1898). This marked a new era in colloidal chemistry in which Zsigmondy was the leader for thirty years. With Siedentopf he developed (1909) the ultramicroscope which in turn led to the further study of the Brownian movement. Explained the precipitation of colloids by electrolytes, protective colloidal action and the speed of coagulation. Synthesized "purple of Cassius" from colloidal gold and tin. Developed the membrane and ultrafilter (1922) with uniform pores of four double *mu* diameter. Received the Nobel Prize, 1925, for his fundamental work in the modern chemistry of colloids.

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The numbers refer to the numbers on the individual sheets

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